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TRANSACTIONS

OF THE

CIVIL AND MECHANICAL ENGINEERS' SOCIETY.

(*Founded May, 1859.*)

50th SESSION, 1908—1909.

(JUBILEE SESSION.)

EDITED BY

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London:

PUBLISHED BY THE SOCIETY,

25, VICTORIA STREET, WESTMINSTER, S.W.

(Telephone, 244 Victoria.)

1909.

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THE

Civil & Mechanical Engineers' Society.

(Founded May, 1859.)

Offices: 25, VICTORIA ST, WESTMINSTER, S.W.

(Tel. 244, Victoria.)

SESSION 1908–1909.

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Civil & Mechanical Engineers' Society.

TRANSACTIONS—SESSION 1908-9.

PRESIDENTIAL ADDRESS

BY

W. NOBLE TWELVETREES, M.I.MECH.E., A.M.I.E.E., M.R.S.I.

[Delivered on October 1st, 1908.]

TO-NIGHT the Civil and Mechanical Engineers' Society enters upon the 50th year of its existence, and I feel that all members, both present and absent, will agree with me that the occasion is an appropriate one for some remarks upon the past history and future prospects of the institution.

In his Presidential Address of December, 1886, Mr. E. H. G. Brewster gave a short history of the Society then at the age of twenty-seven years. Mr. Brewster said on that occasion:—

> "There is no particular magic in twenty-seven years, but as our silver wedding day was not held as a festival, I thought that to wait for our golden wedding might be too long a time for many of us to look forward to, and it would enhance the difficulties, if we did so, of getting together the early history of the C. & M.E., as old members familiarly speak of our Society."

It certainly was a happy idea to set forth the early history of the Society in the Address to which I refer, and now that the Jubilee Session has at last arrived, the records collected by Mr. Brewster furnish valuable data for the account which I present to you this evening.

The Civil and Mechanical Engineers' Society was founded in May, 1859, by a number of the pupils and draughtsmen at the works of Messrs. Ravenhill and Co., marine engineers, Ratcliffe. The first President was Mr. G. W. McGeorge, M.Inst.C.E., and the first Vice-

President, Mr. A. F. Yarrow, M.Inst.C.E. Meetings were originally held at 7.30 p.m. on the first and third Wednesdays of every month, the place of meeting being the St. Francis Schoolrooms, Arbour Square, Stepney.

The title of the Society at the outset was the same as that borne to-day. This point is made clear by a printed copy of the rules and by-laws in the possession of Mr. Yarrow, the first rule in that document commencing "That this Society be called the Civil and Mechanical Engineers' Society."

It may not be quite clear in the present day why a compound name of the kind should have been chosen. We must remember, however, that the rapid development of practice in the design and construction of steam engines, boilers, iron shipbuilding and machinery in general during the first half of last century led to the recognition of mechanical engineers as a class distinct from those described as "civil" engineers.

The facts that the Institution of Mechanical Engineers was founded in 1847 to promote the science and practice of mechanical engineering in all its branches, and that, in 1857, the Putney Club (now the Society of Engineers) discussed the advisability of accepting as a title "The Society of Civil and Mechanical Engineers," are sufficient to indicate the distinction then drawn between "civil" and "mechanical" engineering. Even in recent standard works of reference the application of the prefix "civil" is confined to engineers practising in the construction of railways, roads, harbours, docks, bridges, water supply and drainage systems, and various public works.

There is, in fact, no authority or justification for such a limitation, but its existence at the period of which I now speak was sufficient to account for the title bestowed on this Society.

Although originated by a small nucleus of young marine engineers, the proceedings of the Society were not limited to that department of work. The first paper of which any record remains was read on December 7th, 1859, on the subject of "Railway Curves," and before May, 1861, a number of draughtsmen and pupils at the Stratford Locomotive Works of the Great Eastern Railway Company joined the Society, among them being Mr. W. H. Maw, the editor of *Engineering*, who filled the office of President from 1863 to 1865. Further evidence of the interest attaching to the organisation among those concerned in railway work was furnished by the influx of members from the Engineer's department at Euston.

One of those so coming from the London and North-Western Railway was Mr. G. J. Crosbie Dawson, M.Inst.C.E., engineer to the North Staffordshire Railway.

Mr. Crosbie Dawson, elected as a member in 1860, filled the office of treasurer for nine years, from 1860 to 1869, and at one time never missed a meeting.

In 1860, Mr. Walter Rutt, who joined the Society during 1859, was elected secretary, and has retained his membership to the present day, but, holding an appointment in the department of the engineer-in-chief to the South Australian Government, he is naturally a somewhat infrequent attendant at our meetings.

As the only member on the rolls who was elected during the first year of the Society's existence, Mr. Rutt is actually the "father" of the organisation, and I gladly seize this opportunity of expressing the hope—I am sure with your hearty concurrence—that he may live for many years more to enjoy his paternal dignity, and of assuring him that we his children, and some few his friends and companions of old, are not unmindful of his existence.

Mr. J. B. Walton, M.Inst.C.E., a well-known railway engineer elected in 1860, shares with Mr. Rutt and Mr. Crosbie Dawson the distinction of being one of the three oldest members of the Society, and who took part in the meetings held in Arbour Street, Stepney.

Probably owing to the wider membership, the need for a more central meeting-place was felt towards the end of 1860. Accordingly the headquarters of the Society were moved in 1861 to the Poultry Chapel Schoolroom, then to 8, Moorgate Street, and afterwards to 7, Salisbury Street, Strand.

On September 20th, 1861, a communication was received from the "Young Engineers' Scientific Association," consisting mainly of assistants and pupils in the office of Mr. W. Humber, proposing amalgamation with the Civil and Mechanical Engineers' Society. After due consideration and joint meetings, the project of amalgamation was carried into effect in October, 1861. Mr. F. Campin was the first President after the amalgamation, and Mr. F. H. Roberts was elected Secretary—an office he occupied for eight years. At the same time, the place of meeting was changed to Freemasons' Tavern, Great Queen Street, and there remained until October, 1863.

In 1862 one of our oldest and most honoured members, Mr. G. Eedes Eachus, M.Inst.C.E., joined the ranks as a member, and afterwards filled the office of President for

two sessions. Mr. Eachus for many years was in the engineer's office of the Metropolitan Board of Works, and took part in various important engineering works carried out by Sir Joseph Bazalgette. He is still actively engaged in municipal engineering, and retains a keen interest in the welfare of this Society, with which he has been connected for nearly 47 years.

Mr. F. E. Cooper, M.Inst.C.E., should also be mentioned here as a member of very old standing, having been elected in the year 1863, and ranking fifth in order of seniority among those who remain of our earliest adherents.

The Session 1863-4 was marked by removal of the meeting-place to Drummond Chambers, Adelphi, the election of Mr. W. H. Maw, M.Inst.C.E., as President, and the very successful conversazione held on June 4th, 1863. At the latter six short papers were read, two of these being "On the Sun," by W. Rutt, and "Railways in Parliament," by J. B. Walton.

Mr. Maw occupied the chair until 1865, and was followed for two Sessions by Mr. G. Eedes Eachus, the Whittington Club, Arundel Street, Strand, then becoming and continuing to be the place of meeting until 1869.

In 1866, Baron Siccama, M.Inst.C.E., joined the Society, of which he is still a member and a welcome though only an occasional attendant at our meetings owing to his residence abroad.

Mr. Benjamin Haughton, an engineer connected with the London and North-Western Railway, was President during the Sessions 1867-8 and 1868-9.

In the year 1869, Mr. F. H. Roberts was succeeded by Mr. G. W. Usill, A.M.Inst.C.E., as Secretary, and the meetings took place for two years at 4, Westminster Chambers, being next transferred to 7, Westminster Chambers, which proved a permanent address for sixteen years.

Six changes in the secretarial office occurred between 1870 and 1880, when Mr. G. A. Pryce-Cuxson, A.R.I.B.A., became Secretary, and filled that position with conspicuous ability until 1888.

Among the occupants of the Presidential chair between the retirement of Mr. Haughton and 1887 there are some who cannot be passed over.

Mr. J. B. Walton, M.Inst.C.E., whose membership dates back to the Arbour Square epoch, was President during the Session 1870-1.

Mr. G. W. Willcocks, M.Inst.C.E., now Chief En-

gineering Inspector, Local Government Board, and a member of nearly 43 years' standing, was elected President in 1874.

Mr. H. V. F. Valpy, M.Inst.C.E., a railway engineer of wide experience, became President in 1877.

Mr. H. Ellis Hill, M.Inst.C.E., a constant supporter of the Society for nearly 35 years, occupied the chair during the Session 1880-1.

Then, in 1881-2, came Mr. A. T. Walmisley, M.Inst. C.E., who has achieved equal distinction in the departments of structural steelwork and harbour engineering, and whose connection with this Society extends back to the year 1868.

Other Presidents during the same period were Mr. R. H. Twigg and Mr. E. H. G. Brewster, the latter having been a zealous supporter of the Society and a regular attendant at its meetings for more than 36 years.

Since 1887 the meetings of the Society have been held at various places in Westminster, choice having finally settled on the Caxton Hall, which has provided the requisite accommodation for the past six years.

During the same period the Presidential chair was occupied by Mr. Reginald E. Middleton, Professor Henry Adams, Mr. C. T. Walrond (our present Treasurer), Professor Robert H. Smith, Mr. C. T. A. Hanssen, Mr. W. B. Esson, and others.

Since 1898 Mr. A. S. E. Ackermann has occupied the position of Secretary, and to his untiring efforts the existing prosperity is largely due.

Having briefly outlined the history of the Civil and Mechanical Engineers' Society to the present date, the next subjects for attention are the objects of the Society and the manner in which these are attained.

The primary aim, as defined by the founders, is "the discussion of scientific subjects, especially those connected with engineering." By our rules, members "shall be men engaged in the engineering profession or kindred pursuits." The last three words have generally been interpreted so as to admit architects to membership. There is ample justification for such a union of engineering and architecture. The two professions are virtually identical so far as concerns purely structural work, and in modern practice the architect who is able to design an important building in all its details must possess engineering knowledge of no mean order.

Whether architects as a general rule have time to study during their period of training both the artistic and the

constructive branches of building design is a matter very much open to discussion. My personal feeling is that, notwithstanding the valuable work done by bodies such as the Royal Institute of British Architects in furthering theoretical knowledge of construction, the modern architect will find it an increasingly difficult matter to qualify himself as a combination expert in masonry, steel, and reinforced concrete construction, and in the design and installation of steam boiler, engine, and pumping plant, gas and oil engine plant, electric and hydraulic lifts and hoisting appliances, electric light and power systems, heating and ventilating systems, water supply and drainage systems, and the varied mechanical appliances which enter into the equipment of large modern buildings.

At the same time, it is an undoubted fact that many architects possess sound knowledge of constructive work, and those who have a leaning in that direction are admitted to our Society, where they can discuss scientific subjects with engineers in pursuance of the policy we have adopted, and which has been followed by the Austrian Society of Engineers and Architects since the year 1848.

The papers read at our meetings during the past half-century have covered every department of engineering work. Some have been contributed by engineers of wide experience, and others by young engineers. In each case the educational value has been great, although differing in kind. To hear papers by admitted experts is a privilege for those at the commencement of their professional career, but it is a still greater privilege for young men to hear such contributions at a comparatively small meeting, where they do not feel debarred from taking part in discussion or in asking for information on points not clear to them. On the other hand, it is advantageous for young engineers to be called upon to contribute papers themselves for discussion by their equals in age and experience, or even lack of experience. The writing, reading and discussion of such papers is in itself most valuable training, encouraging study, giving confidence in public speaking, and leading to the habit of reflection and the application of theoretical knowledge to practical work.

In addition to its admitted value as a scientific body, the Society has been the means of bringing into bonds of amity successive generations of members, and of establishing permanent friendship among numbers of those who have taken an active interest in its welfare.

Our membership has never been large, for in no period

of its career has this Society attempted rivalry with the Institution of Civil Engineers, or with institutions, societies and associations specially representing individual branches of engineering practice.

Before the year 1867 students were debarred from access to the Institution of Civil Engineers, a fact which was doubtless to some extent responsible for the establishment of our Society, and the popularity it enjoyed during the first eight or ten years of its existence. The subsequent creation of the students' section of the parent institution and its growth to more than 1,500 members in the present year has taken away many who would otherwise have swelled our ranks. Similar recognition of students by other institutions was attended by a like result, until in process of time the Civil and Mechanical Engineers' Society lost its original character of a young engineers' scientific association, and became a mixed body, still receiving many young engineers, but numbering among its members numerous adherents who, through no fault of their own, had become middle-aged or even old by continued fidelity to the organisation endeared to them by early and pleasing associations.

Finally there arose, some fifteen years ago, the Institution of Junior Engineers, a body of young men apparently desiring to meet together and to conduct affairs in their own way without the regulations necessarily imposed on the students' associations attached to the leading professional institutions. Possibly the same desire for independence led the founders to the formation of a separate body, instead of bringing them into the fold of our own Society. Moreover, in the present day almost every technical college possesses an engineering society for students, and, taking all things into account, there is little reason to be surprised at the fact that our membership is low down in the scale of hundreds instead of mounting to thousands.

Nevertheless, our Society continues steadily to pursue the good work commenced by its founders fifty years ago, and I am convinced that of the thousands who have passed through our ranks from first to last not one has ever been able to deny the pleasure and profit derived from his association with the Civil and Mechanical Engineers' Society.

The process of evolution which has somewhat modified the character of our Society has not been without its effect upon another body, whose aims and work are practically identical with our own. I refer to the Society of Engineers, and it is particularly appropriate that I should

mention that Society at this time when a project of amalgamation similar to that advocated years ago by our friends Mr. A. T. Walmisley and Professor Henry Adams, each of whom is a past President of both Societies, has once more been brought forward.

The whole question has been discussed at length by a Joint Committee, under the chairmanship of Professor Henry Adams, with the result that a definite scheme of amalgamation is now before the respective Councils of the two bodies for consideration. The proposals in question make due provision for recognising the status and honourable career of this Society, and I can assure you that our members have no reason to be dissatisfied with the terms of the amalgamation, as foreshadowed in the report of the Joint Committee. As the matter is still *sub judice*, I will not enter into details, but I take this opportunity of stating the conviction that the union of the two Societies cannot fail to be of mutual benefit. Like the working arrangements so popular to-day among railway companies, the amalgamation would effect a considerable saving of unproductive expenditure and duplicate work, and, in virtue of the strength which comes from union, the prestige of the joint organisation would be greater than that of two independent bodies, and its capacity for usefulness to the engineering profession should be correspondingly augmented.

In view of the possibility that we may shortly be directly associated with the Society of Engineers, a few words on the past history of that body will be appropriate.

The Society of Engineers was the outcome of the Putney Club, established in 1854, on the initiation of Mr. R. M. Christie and Mr. H. P. Stephenson, by eight former students of Putney College, the club having been formed "for the purpose of establishing periodical meetings of all old Putney men, regardless of their present professions, its object being to recall old times, see old faces and hear of the fortunes of old friends."

After some monthly meetings had been held in a room provided by Mr. Talmadge, a tobacconist at 221, Strand, the meeting-place was changed to the offices of Mr. Christie, 76, King William Street, E.C. The first meeting of 1855 was held there, when the practice of reading and discussing papers was inaugurated. The paper then read was by Mr. H. P. Stephenson, on "The Rise and Fall of Putney College." In April, 1855, Mr. Shillito read a paper on "The Plurality of Worlds," and on the same occasion Mr. Alfred Williams was elected a member of

the Committee, afterwards becoming Treasurer and Secretary, a joint position he occupied from 1856 to 1894.

At the end of 1855 the club consisted of twenty-five members, a number which was increased to thirty-two at the close of 1856.

As the curriculum of Putney College included engineering subjects, several engineers were found among the early members of the club. Various points of engineering practice were discussed before the system of presenting formal papers was introduced, and engineering gradually began to preponderate among the subjects brought forward by members. Evidence of the difference between the original purpose of the club and its subsequent character was afforded by the resolution carried on December 5th, 1857, to the effect "That the name of the club be altered and called 'Society of Engineers.'"

Thus the social club became an engineering society only seventeen months before the foundation of the Civil and Mechanical Engineers' Society, although, of course, entitled to date back its establishment in another form to the year 1854.

In 1857 the meetings were held at Exeter Hall, first in Committee Room No. 4, and then in the Lower Hall. During the same year abstracts of papers were printed, together with the rules and a list of members, as a pamphlet of twelve pages, constituting Volume I. of the Transactions. The continued increase of membership afterwards led to the adoption of the United Service Institution as the meeting-place of the Society.

It is interesting to record the fact that the late Mr. Perry F. Nursey, who rendered great service to the Society as member, President, Treasurer and Secretary, introduced nearly 200 members. The Society owes much also to Mr. J. W. Wilson, Principal, and Mr. Maurice Wilson, Vice-Principal, of the Crystal Palace School of Practical Engineering, whence a constant stream of associates and members has emanated for many years past.

Before passing away from the Society of Engineers, I must mention the valuable feature introduced in the year 1863 of paying visits to works of engineering interest, a practice afterwards adopted by our own Society and various kindred bodies.

Having dealt with the history and work of the Civil and Mechanical Engineers' Society, and the association with which we may be allied, I turn next to some of the representative engineering institutions of the United Kingdom, the Continent and America.

Foremost among these is the Institution of Civil Engineers, although in point of seniority the first place must be given to the Smeatonian Society of Civil Engineers, founded in 1771, and still surviving in a form which is rather in the nature of a social club than a scientific association.

Before 1771 engineers engaged in public works "often met accidentally in the Houses of Parliament and in courts of justice, each maintaining the propriety of his own designs, without knowing much of each other." It was suggested to Smeaton that such a state of the profession was undesirable, and that it would be well if occasional meetings could be arranged where engineers might shake hands and become personally acquainted, that in this way sharp edges might be rubbed off, as it were, by a closer communication of ideas not in themselves naturally hostile, that the true end of the public business in which engineers should happen to meet would be promoted "without jostling one another with rudeness, too common in the unworthy part of the advocates of the law, whose interest it might be to push them on perhaps too far in discussing points in contest."

Smeaton promptly acted upon the proposal, and in March, 1771, a small meeting was held at the Queen's Head Tavern, Holborn. Similar gatherings took place every Friday evening, and in 1791 the society, or club, comprised 65 members, although only 15 of these were actually engineers. It is recorded that "Conversation, argument and a social communication of ideas and knowledge in the particular walks of each member were at the same time the amusement and the business of the meetings."

Owing to some misunderstanding among the members, the association was dissolved in 1792. Steps were immediately taken for its reconstruction under the title of "The Society of Civil Engineers."

Smeaton agreed to continue his membership, but died before the first meeting, which took place on April 15th, 1793, at the "Crown and Anchor," in the Strand.

The constitution of the Society provided for three classes of members:—(1) Real engineers, (2) men of science and men who had studied civil engineering, and (3) artists and others connected with the profession. Members dined together every alternate Friday during the Session of Parliament, and it is stated that "a tribute was always paid after dinner to the memory of their late worthy brother, John Smeaton."

All the manuscripts, designs and documents left by Smeaton were purchased by Sir Joseph Banks after the death of the founder. In February, 1795, a Special Committee was formed, with Sir Joseph Banks as chairman, to superintend the publication of such papers and drawings as constituted reports on public works. The first volume appeared in 1812, and three others were published subsequently.

It is much to be regretted that "The Society of Civil Engineers" failed to recognise, as time went on, the need for an institution on a larger scale, having for its main object the encouragement of scientific knowledge, and providing for the admission of engineers engaged in all departments of mechanical science.

If the successors of Smeaton had been less exclusive, and had realised the fact that small dinner parties and social intercourse could not meet the professional wants of so large and mixed a body as presently became engaged in engineering, it is highly probable that "The Institution of Civil Engineers" might to-day be able to date back its birth to the year 1771, and to ascribe its origin to the precursor of modern engineers, of whom James Watt said: "His example and precepts have made us all engineers."

The inception of the Institution of Civil Engineers was due, in 1817, to "a few gentlemen then beginning life, impressed, by what they themselves felt, with the difficulties young men had to contend with in gaining the knowledge requisite for the diversified practice of engineering."

Accordingly, a small band consisting of William Maudslay, Joshua Field, Henry Robinson Palmer, James Jones, Charles Collinge and James Ashwell resolved to form themselves into a society for promoting a regular intercourse between persons engaged in the various branches of engineering, and thereby mutually benefiting by the interchange of individual observation and experience.

According to a statement published by the Institution, the first meeting was held on January 2nd, 1818, at the Kendal Coffee House, in Fleet Street, but Mr. John Weale, who printed and published vols. I. and II. of the Proceedings at his own cost, gives as the place of meeting the "King's Head Tavern," in Cheapside. On the date mentioned it was agreed to form a society under the title of "The Institution of Civil Engineers." After meetings had been held for two years, it was resolved to elect as President a civil engineer of high standing, and Telford

was requested "to patronise this institution by taking upon himself the office of President."

At that period the institution was so little known that Telford had never heard of its existence, but promptly recognising its possibilities he accepted the chair without hesitation. The influence and work of the new President were most valuable; the institution rapidly grew in importance, and, on June 3rd, 1828, it was incorporated by Royal Charter.

Telford devoted much time and thought to the welfare of this rising society. Its collections were enriched by his bounty, and when he felt the approaching close of life he endowed the institution with a large portion of his library, his professional papers and drawings, and the sum of more than £5,000, the interest of which was to be expended in premiums for original communications to the proceedings.

Regular meetings of the institution were held, first in rooms at 15, Buckingham Street, Adelphi; in 1834 a small house was taken at 1, Cannon Row, Westminster; and in 1838 the headquarters were removed to the present site, where the premises have been successively enlarged and rebuilt to provide adequate accommodation.

From the small beginning here outlined has grown the important organisation including more than 8,500 members of all classes, and providing amply for the needs of students by local associations in various large cities, so that the privileges of the institution may be enjoyed by many who are unable to be present at the meetings held in the metropolis.

In a work edited and published by Mr. John Weale in 1851, I find the remark concerning the institution that "Members are civil engineers by profession, or mechanical engineers of very high standing."

Although not authoritative, this quotation points clearly to the distinction formerly drawn between "civil" and "mechanical" engineering, and leads to the conclusion that mechanical engineers of moderate status were not considered eligible for admission to the Institution of Civil Engineers.

It may be the case that limitations of the kind were partly responsible for the formation of the Institution of Mechanical Engineers in the year 1847, but whether or not that was the case, I think it is abundantly clear that in any event the establishment of an independent organisation has been fully justified by the great development of

mechanical engineering, and the valuable work done by the institution in question.

No definite records remain to show whether the Institution of Mechanical Engineers was the outcome of a meeting at the house of Mr. Beyer in Manchester, or whether it was projected in the house of Mr. McConnell at Bromsgrove. The first general meeting, however, took place on January 27th, 1847, at the Queen's Hotel, Birmingham, where George Stephenson was elected President, and Mr. Miller, Mr. Beyer, and Mr. McConnell were elected Vice-Presidents.

Mr. Richard Williams, of Wednesbury, is now the only surviving representative of that meeting, held nearly 62 years ago.

After remaining for several years in Birmingham, the headquarters of the institution were removed to London in 1877, and, by the courtesy of the Institution of Civil Engineers, the London meetings were held in the hall of the building in Great George Street.

During the first ten years the number of members was small, and remained at the dead level of little over two hundred until summer meetings in the leading centres of engineering were inaugurated in the year 1856. Since that date the membership has progressively increased, until the total represents more than 5,200 members of all classes in the present year.

The summer meeting held in Glasgow during 1856 led to the establishment, in 1857, of the Institution of Engineers and Shipbuilders in Scotland, under the presidency of Professor Rankine, an institution which, like various other engineering societies formed in different localities, has been beneficial to the Institution of Mechanical Engineers and the Institution of Civil Engineers alike.

The Civil and Mechanical Engineers' Society may also claim to have done something in the same direction for the benefit of the two leading institutions whose scope is indicated by our title.

The Institution of Electrical Engineers constitutes a second example of the remarkable success attained by departmental engineering associations within comparatively recent years. Originated in 1871 as the Society of Telegraph Engineers by Colonel Sir Francis Bolton and Major-General Webber, R.E., the rapid advance of electrical science led to the change, in 1881, of the title to "The Society of Telegraph Engineers and Electricians," and in 1899 to the present designation.

The rapid growth of the institution, now comprising

some 6,000 members of all grades, must be attributed in no small measure to the admirable organisation which provides for the interchange of information and ideas among members and students, not only in London but in several Provincial and Colonial centres, each with a local chairman and committee. Moreover, the institution is represented by twenty-five local honorary secretaries and treasurers in various Colonies, the United States and foreign countries, and Sectional Committees have been established for the purpose of affording convenient channels through which members may bring to the knowledge of the Council any questions affecting branches of electrical engineering.

It would be impossible for me to refer in detail to the numerous institutions and societies which have sprung up in the Metropolis and large engineering centres to provide for the needs of engineers making a speciality of certain classes of professional work.

Important examples of such associations are the Iron and Steel Institute, the Institution of Mining and Metallurgy, the Institution of Naval Architects, the Institute of Marine Engineers, the Institution of Mining Engineers, the Institution of Gas Engineers, the Institution of Heating and Ventilating Engineers, the Royal Sanitary Institute, the Institution of Sanitary Engineers, the Association of Municipal and County Engineers, the British Association of Waterworks Engineers, the Institution of Automobile Engineers, and numerous provincial societies for the convenience of residents in particular localities.

National engineering institutions are well represented by the Institution of Engineers and Shipbuilders in Scotland, the West of Scotland Iron and Steel Institute, the Mining Institute of Scotland, the Institution of Civil Engineers of Ireland, the Engineering and Scientific Association of Ireland, and the South Wales Institute of Engineers.

If the membership of all these institutions and societies, all local engineering bodies, and all engineering societies attached to universities and colleges were combined, it is probable that, even after allowing for duplicate and multiple membership, the grand total would not fall far short of 50,000 corporate members, associates and students, and might prove to be greatly in excess of that number.

So enormous has been the development of engineering that, in spite of the enlightened views entertained by the Institution of Civil Engineers as to the wide scope of the profession, and the welcome accorded to engineers of

every class, that admirable organisation, of which we are all justifiably proud, does not represent British engineering as a whole.

The claims of those engaged in constructive works, which, for want of a better designation, were once generally and are still to some extent distinguished as belonging to "civil" engineering, naturally demand so large a share of attention that members chiefly concerned in mechanical, electrical and other branches of work are virtually compelled to ally themselves with departmental institutions and societies, which in turn attract thousands of members and students who do not think it necessary to join the parent institution despite the prestige carried by its name and pre-eminent position.

I cannot refrain, at this stage, from expressing the hope that something may be done in the near future to inaugurate a movement for bringing all engineering bodies into closer union with each other and with the Institution of Civil Engineers.

The munificent offer of Sir William Siemens in 1879 to contribute the sum of £10,000 as the nucleus of a fund for providing a building where the applied science associations might meet under one roof, was a step in the right direction. The same idea has been advocated since that date, but the difficulties involved in such a scheme were always very great, and have been increased by the building projects of various leading institutions. Moreover, the benefits to be derived from a central home of engineering bodies in London would only extend in a limited measure to the thousands of engineers who belong to provincial institutions and societies.

It occurs to me that a more practicable scheme would be to establish a union comprising representatives of all professional engineering institutions, societies and associations.

This union would be a grand central council entitled to speak and act with the combined weight and authority of British engineering. One important direction in which it might advantageously move at the very outset would be in the organisation of conferences similar to those inaugurated so successfully by the Institution of Civil Engineers, but open to all members of all the affiliated institutions and societies.

The branches of engineering work are so numerous to-day that a dozen sectional conferences every year would not exhaust all the subjects available, while, for the convenience of provincial members, other gatherings could be

arranged at suitable intervals in various large engineering centres. By the assembly of engineers in this way for friendly discussion and intercommunication, the first step would be taken towards the ultimate establishment of still closer relations.

While leaving perfect independence of action to all existing professional bodies, the grand central council would be at liberty to discuss matters connected with the education and training of young engineers, to formulate recommendations for consideration by the associated institutions and societies, with the object of bringing into line various existing standards of qualifications for candidates, and to do such things as would further the interests of the profession generally.

I need not take up your time by dilating upon the possibilites of such a union, which, if the status of engineering were recognised by Parliament as in the case of other learned professions, would probably develop into a great central institution, occupying a position akin to that of the Royal Colleges of Physicians and Surgeons, and the Incorporated Law Society, and bringing all British engineers into one fold.

An effort was made four or five years ago to bring the leading engineering societies of the United States into closer bonds by Mr. Andrew Carnegie, who generously offered to provide for the engineers of that country a building of ample proportions, and including all necessary accommodation for administrative and other purposes.

Unfortunately, the American Society of Civil Engineers, having completed their new home in 1897, were not inclined to participate in the movement, the result being that the building erected by Mr. Carnegie has been vested in a board incorporated as the "United Engineering Society," and composed of trustees appointed by the American Institute of Electrical Engineers, the American Society of Mechanical Engineers, and the American Institute of Mining Engineers.

These three national societies and various kindred organisations have headquarters in the building, and share in the use of meeting halls seating from 200 to 1,000 persons. The books belonging to the three founder societies are placed in a spacious library, to which the public are freely admitted.

Although the non-participation of the American Society of Civil Engineers may seem to confirm the restricted use sometimes made of the term "civil engineering," the organisation includes engineers in every branch.

It was founded in New York on November 5th, 1852, as "The American Society of Engineers and Architects," thus recognising the allied character of the two professions, as was afterwards done by our own Society. For several years the membership was very small, and the first formal paper was not read until March, 1855. In 1867 steps were taken to revive interest in the Society, and headquarters were established in the Chamber of Commerce Building, New York.

In March, 1868, the name of the Society was changed to that which it now bears, and in 1872 the first volume of Transactions was published.

After seventeen years' existence the total membership was only 160; after fifty years the number had increased to 2,603, and at the present date the Society includes nearly 4,700 members of all classes.

A particularly useful feature inaugurated in 1869 is the monthly issue to all members of papers in advance of the dates appointed for their discussion, in order to allow every member the opportunity of expressing his views. The advance copies are published in pamphlet form, together with reports of previous discussions and business meetings. These pamphlets constitute the Proceedings of the Society, and they are followed in due course by volumes of Transactions, wherein the subject-matter is suitably collated. The system deserves imitation in this country, especially by some institutions and societies which are needlessly parsimonious in the matter of advance copies of papers.

The American Society of Mechanical Engineers was founded in 1880 "to promote the arts and sciences connected with engineering and mechanical construction." The membership has continuously grown, until the total of 3,366 was attained at the end of 1907.

Under a provision of the Constitution, local sections may be formed in any city, and the papers presented at meetings of the local sections are printed for wider discussion by the central body. This excellent practice is the same as that followed by our own Institution of Electrical Engineers, and is worthy of more general adoption.

The American Institute of Electrical Engineers, although only founded in 1884, already includes more than 5,500 members, and more than 1,000 students. Nineteen branch organisations have been formed by local members in the United States and Canada, and seventeen branches in connection with various universities and technical colleges. The direct association with the institute of students when at college is an admirable feature. There can be

no doubt that it has been of much value to the students, and at the same time beneficial to the institute.

Like the American Society of Civil Engineers, the institute issue monthly Proceedings to all members, and Transactions in the form of one or more bound volumes every year.

As in other American engineering societies, much important work is performed by standing committees dealing with finance, library, meetings and papers, editing, examinations, local sections, standards, code and law. Special committees deal with other matters of interest to the institute and electrical engineers. By this system of devolution considerable relief is afforded to the secretary, and opportunities are given to energetic members for doing useful work. It seems to me that the system is far preferable to that generally prevailing in Great Britain, where nearly all the work of directing an engineering society is thrown upon the secretary, whose energies are not infrequently restrained by the conservative inaction of council members rewarded by office more in recognition of long and distinguished past services than of their capacity for hard work and the aptitude for accommodating their views to the new developments that are constantly taking place in modern times.

Time will not permit more than passing mention of other engineering societies in America, prominent among which are the Western Society of Engineers, the Associated Engineering Societies—comprising eleven or twelve kindred organisations in the United States—the American Waterworks Association, and the Canadian Society of Civil Engineers. Therefore I will devote the few minutes remaining to a brief account of three representative engineering associations on the Continent.

First of these, in order of seniority, is the Society of Civil Engineers of France, founded, on March 4th, 1848, by a number of old students of "L'Ecole Centrale." The constitution provides for the admission of all civil engineers, including industrial engineers as well as all persons occupied in sciences connected with the art of the engineer. In addition to objects common to all engineering bodies, the constitution of the society mentions as special aims the development of sciences applied to great industrial works, the extension of technical instruction among the workmen and foremen of workshops, and the furtherance of efforts to utilise the natural resources and riches of the country to the best advantage by studying questions of industrial economy, administration and public utility.

These three items show that from the first the society has been mindful of practical questions, as nearly a hundred volumes of Proceedings testify to the manner in which the scientific and theoretical aspects of engineering have been considered.

The headquarters of the society for twenty-two years provided extremely limited accommodation. The reading room was capable of seating only three or four persons, and the meeting hall afforded space for but sixty members, of whom two-thirds had to stand. When the premises were at last given up the society included 1,000 members, and it will readily be imagined that the atmospheric conditions on meeting nights were not altogether in compliance with modern views of hygiene. The society moved to their first permanent home in 1870, and, after a further period of twenty-seven years, to the present spacious and handsome building opened in 1897.

After having been in existence for more than sixty years the society numbers some 3,700 members, and occupies a deservedly high position among the scientific institutions of the world.

The Austrian Society of Engineers and Architects is a joint institution which has carried on useful work since the date of its foundation in Vienna on May 2nd, 1846. Besides providing for the discussion of engineering and architectural questions, the society arranges for visits to engineering works, takes interest in exhibitions, publishes a magazine giving particulars of new developments in theoretical and practical work, undertakes research work, and arranges for special conferences from time to time. In addition, the society takes interest in the professional welfare of members as a class, and undertakes the settlement of disputes on technical matters by arbitration. Thus it is actively engaged as a professional as well as a purely scientific organisation.

In view of the need for intercommunication between members in places beyond the borders of Vienna, the society has established numerous branches, which, while governed by the original constitution, are self-governing bodies, electing their own members and officers.

The organisation includes thirty-one associated societies, with the total membership of 10,329 in June last. As only 3,517 members belong to the main society and three affiliated bodies meeting in Vienna, the policy of inaugurating local societies has been amply justified, and the organisation, which is a federation of societies rather than a single society, may be taken as a model for the consideration of those who are prepared to work for the more

intimate connection of British engineering institutions and societies.

In Germany, a land where united effort is conspicuous and conspicuously represented by the Empire itself, there has been for some time an effective union of engineering and architectural societies. The chief body, however, is the Society of German Engineers, an organisation which was founded, in May, 1856, by twenty-three young engineers, and has so thoroughly kept pace with successive developments of engineering practice that it numbers to-day no fewer than 22,430 members.

This vast organisation has not achieved the phenomenal success implied by the number of members merely by providing an arena for the discussion of engineering topics. It has devoted much attention to technical education, the foundation of engineering laboratories, the encouragement and conduct of research work, the publication of technical literature, the promotion of exhibitions, the formulation of standards for structural materials and manufactured products, rules for conducting efficiency tests of steam boilers, the preparation of schedules of fees for engineers and architects (in conjunction with the union of engineering and architectural societies), the inauguration of universal Patent Laws for Germany, and one of its most important undertakings was the partial completion of the Technnolexicon, a task which finally proved to be far beyond the unaided resources of the society.

The Society of German Engineers is certainly a monumental object lesson of success, resulting from solid, persistent and judicious attention to the business for which it was created. I think that the examples set by this association, and by some others which I have already mentioned, may enable British engineers to recognise the fact that the unnecessary multiplication of societies is a distinct evil, involving much useless expenditure of time and money in administrative work, splitting up well-meant efforts so that they are dissipated as so much spray, instead of achieving their ultimate end as a united and irresistible stream.

In conclusion, I take this opportunity of congratulating the Civil and Mechanical Engineers' Society upon the attainment of its Jubilee Session; of conveying to all absent members and those old friends who were once members the cordial greetings of the Council and myself: and, finally, of expressing the hope that this Jubilee Year may prove to be the foundation for the erection of an additional superstructure of increased and ever-increasing usefulness and prosperity.

APPENDIX

TO MR. TWELVETREES' ADDRESS.

The Canadian Society of Civil Engineers, established in February, 1887, and incorporated by Dominion Act in June, 1887, is an institution embodying features of such importance as to demand special notice.

The Society comprises four sections, viz.: Electrical, Mechanical, Mining and General, the total number of members being about 2,000 at the beginning of this year. Each section has a chairman, vice-chairman and recording secretary, and the proceedings of the sections are published in the Society's transactions.

It will be seen from this statement that the organisation is really a society paying equal attention to all branches of civil engineering. In other words, it is four societies in one, and renders unnecessary the schismatic associations which have grown up in England and the United States, possibly because the institutions professing to represent the entire profession of civil engineering have not accepted sufficiently broad views, or have not been alive to the desirability of taking measures at the proper time for keeping all members of the profession within one fold.

The Canadian Society further provides for the establishment of local branches at any place not less than one hundred miles from the headquarters of the Society. Local branches, although formed strictly of members of the Society, are distinguished by the name of their locality, as, for example, "The Toronto Branch of the Canadian Society of Civil Engineers."

Here is another feature of much importance. If the same wise policy had been adopted in this country years ago there would probably be branches of the Institution of Civil Engineers in Manchester, Liverpool, Glasgow and other places, instead of local engineering societies

quite distinct from, and taking some members away from, the parent institution, and creating unnecessary multiplication of professional associations.

The Canadian Society was also constituted by the Manitoba Government in 1896, and the Quebec Government in 1899, the only body capable of qualifying persons to act or practise as civil engineers within those provinces. The standards of education and professional knowledge are very similar to those adopted by the Institution of Civil Engineers, and the Quebec Act provides that, with certain specified exceptions, candidates for corporate membership shall pass an examination on the theory and practice of engineering before being admitted and licensed as civil engineers.

Thus the Canadian Society of Civil Engineers enjoys prestige and authority not yet possessed by any engineering body in our own country, but which, as I have already hinted, might appropriately be conferred upon a general council representing the whole profession in Great Britain.

NOTE.

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"I conceive it to be the duty of every educated person to watch and study closely the time in which he lives, and as far as in him lies, to add his humble mite of individual exertion to further the accomplishment of what he believes Providence to have ordained."—Extract from a speech of Prince Consort on March 21st, 1850.

Sir John Herschel said: "There are epochs in the history of every great operation, and in the course of every undertaking to which the co-operations of successive generations of men have contributed, when it becomes necessary to pause for a while and, as it were, to take stock; to review the progress made, and estimate the amount of work done, not so much for complacency, as for the purpose of forming a judgment of the efficiency of the methods resorted to, to do it, and to lead us to enquire how they may yet be improved, if such improvement be possible, to accelerate the furtherance of the object, and to ensure the ultimate perfection of its attainments. In scientific, no less than in material and social undertakings, such pauses and resumés are eminently useful, and are sometimes forced on our consideration by a conjuncture of circumstances which almost of necessity obliges us to take a *coup d'œil* of the whole subject, and make up our minds *not only as to the validity of what is done, but as to the manner in which it has been done*, the methods employed, the direction in which we are henceforth to proceed, and the probability of further progress."

These words are especially applicable to the strides which have been made in late years towards aërostation. Franklin said of this science, "It is an infant, but it will grow." Aërostation may indeed be well considered as a branch of science which displays, among other qualities, *the largest amount of physical courage in its professors.*

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BALLOONS AND AEROPLANES.

By Capt. W. G. Windham.

[Read on Tuesday, November 3rd, 1908.]

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Everything must have a beginning, and to substantiate

this we only have to look back to the incredible progress made within a short period, from the first steamer launched on the Clyde to the splendid fleets which now visit all the harbours of the world.

Aërostation can by no means be called a new subject. It has been studied for hundreds of years. The eminent Englishman, Roger Bacon, born at Ilchester in 1214, who for his ability and genius was styled the "Admirable Doctor," was the first to whom we are indebted for an approximation to the true principles of aërostation. Like Franklin his ideas and knowledge were three or four centuries ahead of the age he lived in, and within the last hundred years several of his magnificent schemes have been realised. Not only did he assume the possibility of constructing engines of immense size and power that could traverse the land and sea, but he illustrates a plan for navigating the air. He described his aërial machine as being a large hollow globe of copper wrought extremely thin (in order to have it as light as possible). He says it must be filled with ethereal air or liquid fire, and when launched into the atmosphere it would float like a vessel on water. He also goes on to say there may be made some flying instrument so that a man sitting in the middle of the instrument, and turning some mechanism, may put in motion some artificial wings which may beat the air like a bird flying. The art of making gunpowder is attributed to this Roger Bacon.

In *Notes and Queries* of September 5th, 1864, was published an extract from a letter written in 1607 (260 years before). It is supposed to relate to the discovery of aërostation in 1607, and is as follows: "The greatest newes of this countrie is of an ingenious fellow, that in Berkeshire sailed or went over a high steeple in a boat, all of his owne making, and without other help than himself in her, conveyed her about twenty miles by land, over hills and dales to the river, and so down to London."

There are numerous facts to prove that even up to the time when the famous Montgolfiers lived in 1783, the air was looked upon as a ready means towards locomotion.

It is also interesting to note that even so early as the year 1670 (as Mr. Wise, the American historian of aërostation, tells us), Francis Lana, a Jesuit, truly inferred that a vessel exhausted of air would weigh less than when full of that fluid. He quotes as an example that of *two* globular vessels, one 10ft. in diameter and another 20ft.; the first will have a capacity of 523 cubic feet, while the other will have 4,184 cubic feet capacity. The surface of

the larger will be four times as large as the smaller one, while its capacity will be eight times as large. This is a very important consideration in the construction of balloons.

Thus a balloon which would carry one person would weigh 100lb., yet one capable of carrying two persons, costing about £10 more, would not weigh more than 150lb. Now a balloon of the first-mentioned power would be about 20ft. in diameter, and when filled with hydrogen gas would have a lifting power of 250lb., while one over five times its diameter — *i.e.*, 100ft. — would have an ascending power of 32,725lb., and would be capable of lifting 167 men independent of its own weight.

About the year 1643 the barometer was discovered, and has proved useful in the development of aërostation.

Very few authenticated ascents were made before the year 1783, when the famous Montgolfier began to experiment with balloons. He was a native of Ambert, a small town in the Auvergne, where the oldest paper manufacturers in France were established, and to Montgolfier may be attributed not only the initiation of the science of aërostation, but also the manufacture of paper and vellum.

In old St. Pancras Churchyard to-day one may read an inscription dedicated to Tiberius Cavallo, who, about the period 1771 to 1809, lived in London, devoted his time to science, and wrote a book called "The History of Aërostation." In this he described the ascent of one of Montgolfier's balloons before the King and Queen at Versailles on the 19th September, 1783, and, after describing the inflation of the balloon, he says: "They put a sheep, a cock and a duck in it, and they were the *first living creatures that had ever ascended into the atmosphere with an aërostatic machine.*"

The cage came to the ground without hurting the animals which were in it. The sheep were found feeding; the cock had only its wing hurt, but this was in consequence of the kick he had received from the sheep!

Scarcely ten months had elapsed before Montgolfier himself ascended into the atmosphere. The balloon was inflated with hot air; the fuel was thrown on the grate through port holes made in the neck of the balloon. The weight of the aërostat was 1,600lb.

In Great Britain, where the improvements of arts and science find their nursery, and many their birth, it is curious to relate that no aërostatic machine was seen before November, 1783, when Count Zambeccari, an Italian, made a balloon of oiled silk. It was launched

from the artillery ground at Woolwich, and was found afterwards near Petworth, in Sussex.

The next attempt was made by two brothers called Roberts in December, 1783. This was the *first* attempt made by human beings using hydrogen as the lifting power in lieu of hot air. Mons. Charles, who accompanied Mons. Roberts in this ascent, was the first to invent the valve, which to-day is used on every balloon to allow the escape of gas ; he is also given the credit of having discovered the use of varnish to prevent the loss of gas through the silk.

One of the first ascents was recorded in the *Morning Post*, September 16th, 1784, and described Lunardi's aerial excursion.

The discovery that hydrogen was a suitable gas for balloons, and was about 1-15th the weight of air, caused men to take up ballooning. One of the first of the balloons filled with hydrogen to make an ascent was made in August 1783. It took 1,000lb. of iron and 498lb. sulphuric acid to make the hydrogen to fill the globular bag of varnished silk, which for the *first time* was called a *balon*, which meant, in French, a ball, or what we term a balloon.

Most of the balloons which one sees in London during the season are made of silk and varnished with a composition of dissolved rubber, but even with this addition it is impossible so to treat the silk as to entirely prevent the gas leaking out.

The military balloons are constructed of gold-beaters' skin, which allows the balloon to be made smaller for transportation purposes, as hydrogen, although much lighter than coal gas, is far more elusive.

During the years 1783 to 1785 the first pilot balloon crossed the Channel, four ladies made an aerial ascent, and Madame Thible made the first ascent in a fire balloon, Blanchard and Dr. Jefferies crossed the Channel for the *first* time, and for the first time on record it was seen that for a balloon to be serviceable to mankind it was necessary to use power other than the currents of air to propel it. So, in 1784, oars were fitted to the basket of the balloon, but all they did was to tilt the basket at an angle away from the body of the balloon.

Russia, generally speaking, is about a hundred years behind our country in its politics and administration, yet it is far ahead of all other countries in aërostatics. General Kavanko, who is the head of the army balloon department, is a scientist of the highest order, and is credited with possessing the largest and most up-to-date

library and collection of matters relating to aërostatics in the world.

Mr. Hatton Turner has written probably one of the finest books ever published on aërostation. It contains some 520 pages of closely printed matter, and gives the roll of the first five hundred aeronauts who lived between the years 1783 and 1848, the expense of the compiling of this book being at least £500 for the manuscript and photo-zincographs illustrating it.

The publishers, however, lost these, and all the valuable manuscript was lost. *A propos* of this, the author was talking to Gen. Kavanko, the general commanding the balloon corps in Petersburg, who said, talking of the book: "Yes, I know it well. I have all the original manuscript. I bought it from a caretaker in London for £40." So you see, Russia is not quite so fast asleep as people are inclined to think.

There is a Mons. Tatarinoff in Petersburg who has one of the best aeroplanes in existence, and has been many hours in the air. His claims are that he has discovered a principle by which the effect of gravitation can be largely overcome, and the reliability of this principle has been conclusively demonstrated in the trials of four machines, each an improvement on its predecessor.

During the period 1783 to 1849 there were some 500 authenticated balloon ascents, and it is interesting to note that the English ascents (and aeronauts) more than doubled those of the French, and one is struck with the comparative rarity of accidents. Taking ordinary care, there are few so-called sports which are attended with so few accidents. The chief danger in a balloon lies in the landing, especially in a breeze, but, owing to the recent adoption of a ripping cord, a rent of several feet can be suddenly made in the top, thus preventing the balloon from dragging while the gas is trying to escape.

The first man-carrying device was invented by the Marquis de Bocqueville, who used to sail or glide from his house (without using any kind of mechanism) over the Tuileries to the south bank of the Seine.

The first dirigible balloon of any consequence was "La France." In 1884 it made a short circular tour, returning to its starting point. This also was considered a wonderful performance. It measured 180ft. by 28ft., and was fitted with a small De Dion motor of 8½ h.p. It could travel "when the air was calm" at 13 miles an hour. Since this period several dirigibles have made their appearance, among the most notable being one of M. Santos

Dumont. There have also been the French military balloons, the "Zeppelin," and latterly our own "Nulli Secundus," which made a tour from Farnboro' to London, passing round St. Paul's to the Crystal Palace, where it was wrecked by a high wind. The "Nulli Secundus" was 132ft. long by 25ft. diameter; it held 60,000ft. of gas, and was fitted with a 40 h.p. engine

In October, 1901, M. Santos Dumont succeeded in gaining the Deutsch prize. He flew from St. Cloud, a suburb of Paris, round the Eiffel Tower and back again.

Mons. Lebaudy was the next to come into prominence, and he built the famous "La Patrie," and made some wonderful performances in 1905. So satisfactory were they that the French Government ordered several more of the same pattern. "La Patrie" was 160ft. long and 28ft. diameter. It travelled in 1906 from Moisson to Chalais-Meudon, a distance of 31 miles, in one hour ten minutes, against a strong beam wind, a very creditable performance.

It was fitted with a 75 h.p. Panhard engine, and was of the usual French cigar-shape pattern.

Nearly all the nations have accepted this pattern as the best for a dirigible, except that they are now mostly fitted with a bag below, which acts as a keel.

Following "La Patrie," which was blown away in a gale and carried to somewhere on the coast of Ireland, came "La Republique," which was fitted with a 65 h.p. Panhard engine, and measured 185ft. by 35ft. in diameter.

In 1906, Count Henry de la Vaulx ascended in his dirigible to a height of 4,000ft., and then came the "Ville de Paris," built by Mons. Deutsch, who has offered £1,000 for the *Daily Mail* cross-channel flying competition.

The most notable among the German dirigible balloons are the "Zeppelin," "Parseval," and "Gross."

The "Zeppelin" is rigid, and divided into several parts (like the water-tight compartments of a ship), and is made of aluminium. "Zeppelin No. 4," the largest aerial transport yet constructed on the Continent, was a large craft about the size of an Atlantic liner, requiring 12,000 cubic feet of hydrogen gas to fill its seventeen compartments at a cost of £360. It used 120lb. of benzine per hour for its motors, and required to carry *one and a-half tons* of benzine for a 24-hours' flight. It cost about £50,000, and could carry only seventeen men, including two for navigation and two for attending to the motors. It covered a distance of 380 miles on its last journey, and while attempting a 24-hours' flight it was destroyed by

fire. The German nation subscribed something like £250,000 to provide a new one. It is just the reverse to this country. We as a nation devote most of our surplus funds to hospitals, lifeboats, etc., which it is clearly the duty of the Government, not the public, to maintain ; and the remainder, instead of being given to some object for the welfare of the nation (balloons or aeroplanes, for example), is spent on charity bazaars or dogs' homes.

Jules Verne, the inventor of the submarine, said, on page 33 of the "English Translation": "If you give a column of air an ascensional movement of 45 metres a second, a man can support himself on the top of it, the soles of his boots having a surface of $\frac{1}{8}$th of a square metre. If the pace be increased to 90 metres he can walk on it with naked feet, and if by means of a screw (or propeller) you can drive the air at this speed, you get the same result."

I am a very great believer in the use of balloons in war, both for naval and military purposes, and I think that neither of these services, especially the Navy, makes sufficient use of the very great advantages which are offered through the use of balloons in war.

Let us take a few examples of the uses to which they could be put. They could be used for watching a coast line or land frontier in anticipation of raids or invasion, and for the observation of large bodies of men at a distance, enabling those responsible to place both the invading and opposing troops, as it were, on a chess-board before them. From a balloon the invaders' strength could be estimated, and the direction in which he was moving ascertained.

Scouts conveyed in airships could obtain information concerning tracts of country within the theatre of war, which were not occupied by the enemy's troops, and consequently open to their own.

Experiments at Aldershot and Berlin have clearly demonstrated that wireless telegraphy can be used in connection with balloons with satisfactory results, and with the aid of field glasses the balloons can be kept out of range of the most powerful long-range guns.

My opinion as to the uselessness of balloons, *except for war purposes*, is corroborated in the *International Magazine* of last month by Mr. John Ledeboer, who says that a "lighter than air" conveyance filled with gas, as distinct from an aeroplane, is deficient in speed and carrying power, the velocity of the wind, especially in high altitudes, being such that dirigible balloons with their huge bulk

offering resistance to the air *cannot* attain a sufficient speed for practical utility. To remedy this larger hulls are being introduced, with the result that more power is required to overcome the increased resistance, which means a consequent increase of weight, so that we move in a vicious circle.

Mr. Edison says: "It is also unlikely that the efforts of the inventors who have pinned their faith in the dirigible balloon will meet with success. When you have something which is lighter than air, it is apparent even to the layman that it is the toy even of the winds; it is wafted about like thistle-down before the wind."

Having described the various forms of balloons under the heading "Lighter than air machines," it is now proposed to deal exclusively with those which are "heavier than air." To do justice to this subject would take more time than is now available; the latter part of this paper, therefore, consists of a short description of some of the better known aeroplanes, and concludes with a more detailed account of the Wright machine.

One thing leads to another. Without the bicycle and the pneumatic tyre, motor cars never would have reached the perfection which they have to-day, and this holds good with regard to the aeroplane and the petrol engine. It is only natural that our friends and neighbours, the French, are doing their utmost to keep the aeroplane trade in their own hands, as they did in the case of motor cars.

In England no one seems to take the slightest interest in aeroplanes, whereas in Paris it is exactly the opposite. Even the workmen are enthusiastic, and every preparation is being made to capture the flying-machine trade.

There is undoubtedly a big opening for the manufacture of light engines for aerial work. The engine of to-day is too heavy and cumbersome for use in aeroplanes, and the author predicts that to meet the requirements of the aeroplane will necessitate the entire reconstruction of the modern motor-car engine.

The well-known firm of Renault Frères has constructed an 8-cylinder engine, developing 45 h.p., with a total weight of 208lb., including the cooling apparatus, magneto and carburettor.

The engine most generally used is the Antoinette; it was originally designed by Levasseur for aeronautical purposes, and was used later on for boat work, but it is so reduced in weight that it cannot be relied on for general use.

The commercial realization of the aeroplane cannot be

far off, and one has only to watch the efforts of such men as Ferber, Farman, Bleriot, Delagrange, Wright and others to see that they are determined (now that the start has been made) to conquer the air. Nadur has said: "Give me an engine of 1 h.p. in a watch case, and I realize the possibility of flying." We have to-day engines of 100 h.p., weighing only 275lb. all told—*i.e.*, under 3lb. per h.p.; but there is not one of them which can be relied on to work even for a short period without stopping. The reason for the success of the Wrights' machine is that whereas the ordinary planes used by Farman, Delagrange, Ferber and Bleriot are constructed to rise from the ground, the Wrights' machines is *shot off* (as it were) by letting fall a heavy weight from a tower. When once an aeroplane has attained the necessary speed to allow it to fly, then it does not require much to keep it going. Wright uses a 4-cylinder, 4-cycle engine of about 26 h.p.; but to make the machine rise into the air with the necessary velocity is another matter. It is necessary to have sufficient power in the engine to drive the aeroplane up a rise of about 1 in 8 at about 45 miles an hour; but once in the air with a level keel a lot of the power could easily be dispensed with.

Everything possible is being done both here and abroad to reduce the weight of the engine. Eight cylinders are employed, and the fly-wheel dispensed with. The engines are automatically fed with petrol, so doing away with the carburettor, and reducing the size of the magneto, and such parts as the crank chamber, etc., are made in aluminium to keep down the weight.

A SHORT DESCRIPTION OF SOME AEROPLANES.

The Bellamy Aeroplane.

This machine is an invention of Mr. Bellamy. In its design it is like a bird with wings outstretched. A two-bladed propellor is fitted in front, where the engine is also placed. The whole apparatus is supported on a tube framework, this again being suspended on three pneumatic-tyred wheels, two in front and one behind.

Farman's New Machine.

The whole aeroplane weighs 650 kilograms. The carburettor is of aluminium, and the magneto is made especially small. The motor has eight cylinders, 35 h.p., constructed by Renault Frères, and arranged in V fashion.

It is air-cooled by two fans, and weighs 130 kilos. The steering-wheel is a novelty; it acts ordinarily on the vertical rudder, but when moved horizontally it works on the horizontal rudder. The wings are made in cloth, with the exception of the driver's window, which is in mica. The body is of ash, 46ft. long, the members being connected by steel wires and wooden ties. The rectangular wings are each 8ft. 8¼in. long and 1ft. 3in. wide. The second plane is placed lower than the first, and the third lower than the second. Lastly, the whole is mounted on two wheels placed well forward, and the third at the-tail.

Mr. W. R. Kimball's Helicopter.

Mr. Kimball has invented a machine of the type which Mr. Edison predicted would conquer the world. It consists of twenty-four small wooden propellers set in a horizontal plane. The air is forced downwards instead of astern. It has an inclined wing, which varies the horizontal angle, and a large rudder which steers it. It is constructed of wood and aluminium, and is strengthened with piano wires. The whole of the twenty-four small propellers are worked from one engine.

Another plane which has lately made its appearance at Issy (the trial ground for aeroplanes, near Paris) is in form and appearance like the Wrights' machine. It is American, and is known as the "June Bug." The chief difference between this and the Wright type is the ends of the main planes converge towards each other. It is fitted with an 8-cylinder Curtis engine, which drives it at about 45 miles an hour. It recently gained the 2,500 dollars prize offered by *The Scientific American* for flying a kilometre in a straight line.

Farman's "Flying Fish."

This is the third plane which M. Farman has made, and although it differs in a few details to the others, it practically embodies all the former ideas, with the exception of the planes. Three of these are larger than the other two, the larger ones being in front and the smaller two behind, these looking very much at a distance like large steps, rising one above the other.

The over-all length is 14 metres, and the spread of the larger planes is 6½ metres. The driving is effected by a tractor screw in front. All the planes are under the control of the aviator, and can be altered at will.

The Progress of Flying Machines.

There are few people who realize that in 1905 the Wrights flew a distance of 24½ miles. Their flight was not officially recognised, and consequently these distances and flights cannot be recorded. Progress in flying starts, therefore, officially from September, 1906, when Santos Dumont flew for two seconds, covering a distance of 10½ yards. To show with what rapidity the distances have been increased, I will give them in order, quoting the time each aeroplane was actually in flight:—

Nov. 1906: 21 1-5 secs.—Santos Dumont.
Oct. 1907: 52 3-5 secs.—Henry Farman.
Jan. 1908: 1 min. 28 secs.—Henry Farman.
Mar. 1908: 3 min. 31 secs.—Henry Farman.
April 1908: 6 min. 30 secs.—Delagrange.
May 1908: 15 min. 26 secs.—Delagrange.
July 1908: 20 min. 19 secs.—Henry Farman.
Sept. 5, 1908: 19 min. 50 secs.—Wilbur Wright.
Sept. 6, 1908: 29 min. 53 secs.—Delagrange.
Sept. 9, 1908: 1h. 3m. 15s.—Orville Wright.
Sept. 11, 1908: 1h. 10m. 30s.—Orville Wright.
Sept. 12, 1908: 1h. 14m. 20s. (equivalent to 45 miles)

Thus in two years the distance traversed was increased from 10½ yards to 45 miles.

M. Delagrange was the first to carry a passenger on an aeroplane. He flew 60 yards with Mr. Farman, and thereby won £480. Mr. Farman was the first to fly a complete circle on an aeroplane, doing 1¼ miles in 1½ mins. He also gained a prize of 1,000 francs for being the first aeroplanist to remain more than 15 minutes in the air. This he did at Issy, covering a distance of 12½ miles in 20 mins. 21 secs.

Santos Dumont in 1902 flew in an airship for more than half an hour, and in 1906 his 32ft. aeroplane came to grief after a short flight of 25 yards. Later in 1906, he travelled 83 yards, and again 240 yards, at a speed of 25 miles an hour, and at a height of 20ft. He was awarded two prizes, one of £21 for being the first to fly a distance of more than 195ft., and the other was for covering a distance of 325ft. without touching the ground.

The Wright Aeroplane.

The aeroplane as used by the Wright Bros., Delagrange and Farman is a combination of the theories of Langley and Chanute. Langley used the cellular structure in tan-

dem so to obtain longitudinal stability, and Chanute widened the base to make the planes more rigid. By dividing the planes a bi-plane of 10 metres is obtained, instead of a monoplane of 20 metres, the actual surface of the plane being cut in half. The planes are each 40ft. in length, 6½ft. wide and 6ft. apart, fixed one above the other, the uppermost surface being convex, the deeper curve being to the front. The front edges of the wings are moveable.

Piano wires are led from a lever placed by the side of the operator, and pass over pulleys fixed to the base and the top of the upright supports, so that when the lever is worked the wires pull the edges down or up, as the one is dropped downwards in a curve, the other is straightened, or *vice versâ*.

The lever controlling the vertical tail rudders is placed by the side of the lever which manipulates the tips of the wings, so that both levers can be operated by one hand, leaving the other free to raise or lower the horizontal (or lifting) planes, which raise or lower the nose of the machine.

The engine is a 4-cylinder 4-cycle motor of about 26 h.p., and it has no carburettor, the petrol being fed automatically into the feed-pipes, where it is vaporised and drawn by a pump into the cylinders. I have been told that the engine is very apt to misfire, possibly because it gets too much petrol (as was the case with M. Bleriot's machine on the 25th of last month, and which nearly caused his death), or because the petrol is not strained.

The speed of the plane can be more or less governed by the wings. Each wing extends for two-thirds of the length of the machine, and practically the whole of the wing is moveable, so that with two-thirds of the surface set obliquely to the direction of flight, it is almost sufficient to stop the aeroplane even with the engine developing 26 to 30 h.p.

The engine is placed on the right, the operator sits to the left, and, as the seat is made for two, he can, by altering his position, help to balance the machine. In front is a bar on which the operator places his feet. Skids or runners are placed under the machine, and are used for the purpose of landing. The wheels are not used for landing, but simply to wheel the aeroplane about on, and can be folded up or removed. The launching is done by means of a tower, from which a weight is released, and the aeroplane, which is placed on rails, is shot forward, giving it the necessary speed to enable the machine to

rise. The propellers turn about 450 revolutions per minute. There are two of these fitted, and they turn inwards like some ships' propellers.

The complete machine, together with the operator, weighs about half a ton, giving a lift of 2lb. to the square foot, allowing 500ft. of surface.

In order to gain an idea of a flight, you must imagine seeing a large flat piece of ground, quite level and with no obstructions, such as telephone wires, trees, houses, etc., to mar the view. The aeroplane (Wright's) is placed on a single rail facing the wind; the engine is put in motion, the operator takes his seat, together with a passenger (if he can find one), the machine is balanced by a mechanic, who holds on it; the cable is slipped, and the aeroplane rushes forward together with the mechanic, who holds on as long as he can; he then possibly goes head-over-heels, and, amidst the roar of the propeller, the machine glides off the rail, the forward horizontal planes having been slightly tilted, it lifts itself off the rail and into the air. If wishing to turn to the left, the operator raises the right wing, and the machine swings round like a bird, with its right wing up and the left down, at an angle of about 35 degrees. To descend the operator pulls a string; the engine stops, and the plane gradually coasts down at an oblique angle, the easy manner in which it descends being very pretty to watch. Those machines fitted with wheels run along the earth 100ft. or so before they finally stop, and one occasionally sees the operator jump out and hang on behind to stop it.

Another inventor, Mr. Schroeder, has taken an entirely new line of his own in regard to his ideas of conquering the air. He has taken as a model for lifting purposes the action of the bee, and, after a very careful study of the flight of this weight-carrying insect, has approached as near as possible the motion of its wings. In some ways it presents the appearance of a ship with horizontal sails, yet it combines something of the aeroplane and also of the dirigible balloon. The lifting power of this ship is supplied by a series of rotating sails or wings, each rotating on a vertical axis, but in opposite directions, or, to put it in a simpler way, he has a series of canvas sails or wings, which rotate round a series of masts. One of the chief features of his invention is that it is possible to rise almost perpendicularly from the earth into the air. The machine requires no great space to manœuvre in, and it needs no rails to launch it into the air. The horizontal propulsion is much the same as used in other machines.

It may interest some of you who may be thinking of designing an aeroplane that it is *in the balancing* and placing the centre of gravity right that the secret of building an aeroplane consists. At least, that is my belief. The Wright Bros., in their experimenting days, tried placing the weight below the centre of gravity ; they also tried placing the wings in a V shape, like a butterfly ; but in both cases (to use their own words) "like a pendulum it tended to seek its lowest point, yet also like the pendulum it tended to oscillate in a manner destructive to all stability." Also with the V-shaped wings it not only tended to oscillate, but its usefulness was restricted to calm weather.

There are many interesting points to which there has not been time to refer, so that if any of you will comment on this paper or give your own views, it will no doubt prove most interesting.

THE INFLUENCE OF TRACK UPON RAILWAY AND TRAMWAY CARRIAGES.

By James Sutherland Warner, A.M.I.Mech.E.,
Member of the Tramways and Light Railways Association.

[Read on Thursday, December 3rd, 1908.]

If we search through the technical records which constitute the history of traction upon rails, we find that the writers, without exception, have considered their subject only from the point of view of the application of the propelling power, and, while dealing with questions of economy and the general running of trains of carriages, have invariably neglected the important influences which a pair of rails, by reason of their essential characteristics, exert upon any carriage passing over them.

Indeed, except in investigations relating to the passage of rolling-stock over changes of direction of the track, such as curves, the momentum of the mass seems to have been overlooked or ignored to an extent which, having regard to its importance, seems almost incredible.

Nor is this charge of neglect to be aimed alone at those who have in the past published their experiences or conclusions concerning transport over rails. If we examine, either from the siding or as passengers, the finest examples of railway or tramway carriages in service in any country of the world to-day, we shall see that the designers have neglected the uniform tendency of momentum.

The author having just returned from a tour, during which he has travelled about 5,000 miles over the principal railways of Europe, avers, without fear of contradiction, that in the matter of easy running and comfort there is absolutely nothing to choose between them. He is prepared to go further, and say that the continual vibration and oscillation of the carriages is a perpetual discomfort and torment, which is absolutely unnecessary and a positive disgrace to railway engineering science.

The subject is an almost inexhaustible one, and it is impossible within the confines of a single paper—present-

ing, as this paper does, a number of entirely new conceptions or definitions—to consider more than the first principles ; and even these considerations must for the same reason be confined mainly to straight track, and the influence of the pair of rails which comprise the track, upon the carriages which they support and steer.

In spite of the economical importance of the oscillation of rolling-stock, no method of any kind was in existence for testing and recording the oscillation of carriages until the publication of the author's "Warner Lines" method by the Tramways and Light Railways Association,* particulars of which are given in the appendix to this paper. At first sight this is not of great importance, but the author contends that the absence of any such test indicates lack of scientific treatment concerning the inter-relation of track and carriage. A little consideration will show that the mere record, continuous or intermittent, of the precise relation at any instant of the carriage to the rails themselves, would be of no practical value whatsoever, for the simple reason that a carriage never follows the track with exact precision, nor is it desirable that it should do so.

The universal practice of connecting the body and the track in the vertical plane by means of springs is alone sufficient to justify this statement.

In this paper, for the first time, definitions are given of the "chance line" (Definition 10), which all existing rolling-stock may be said to follow, and the "conformity line" (Definition 7). This latter is the author's traction trajectory, or ideal, line which he would have all rolling-stock designed to follow. In the absence of these as reference lines neither oscillation tests nor precise scientific communications are possible.

It is certain that we can never form a clear and reliable estimate of the influence exerted by rails upon the line of motion of a carriage for any given set of conditions unless we first ascertain and clearly define the influence of the same track surface in plain form—*i.e.*, without rails, and therefore without the perpetual influence peculiar to rails.

This brings us at once to two definitions, the first of which—the "rolling line"—purposely ignores inertia, after which we shall consider Definition 2, the "velocity line."

"The 'rolling line' is the line along which a vehicle would roll over a plane surface if it followed the irregularities of that surface."—(Definition 1.)

As an example of a plane surface we may take a hard,

*Vide Official Circular of the Tramways and Light Railways Association, May 1907.

well-paved city square. If we remove a bogie truck from the railway track, and study its movements when the wheels rest upon a plane floor, we shall observe that there is a certain line along which the truck will move to and fro, with the exertion of much less force than would be necessary to move it in any other direction. If the wheels are larger in diameter, or the axles nearer to each other on one side than the other, this "rolling line" may curve to the right or left, but it is important to note that this line has a definite *direction*; that the straight or curved characteristic of a given truck will remain constant, while the direction will be affected very little by irregularities of the level surface, and that the "rolling line" made by the truck over a given run will tend to be repeatedly the same.

Since a mathematically perfect surface cannot exist in practice, the "rolling line" can never be a perfect right line. Even granted a perfect plane surface, since mathematically parallel or straight axles, or equal wheel diameters, are not practicable, the "rolling line" must still be irregular. In the "rolling line" inertia is ignored, the definition being employed with reference to direction and uniformity.

The "velocity line," on the other hand, although not a line which we shall afterwards use in connection with rail traction, has a similar definition to that of the "rolling line," but includes the consideration of any elasticity or yielding in the path or the truck arising from the inherent irregularity of the path being opposed to the inertia of the truck, together with the effect upon the uniformity and direction.

"The 'velocity line' is the line which would be generated by a point at the centre of the mass of a vehicle actually rolling over a given plane surface."—(Definition 2.)

It is important to note that the reason for using the word "velocity" to define this line is that, with a given vehicle passing over a given plane surface, this line would be the same for similar speeds, and with varying speeds it would not only vary in uniformity, but also in direction and balance; and the tendency of the vehicle to overturn, and thus produce loops in the line, is only a question of relative velocity.

So long as we are considering the action of vehicles over plane surfaces, the "rolling line" (which may be said to be a constituent of the "velocity line") is of minor importance from a practical point of view, and the "velocity line" or effective line of transition is all important. When, however, we come to define the lines of movements

of vehicles as they are influenced by rails, the "rolling line" becomes an important conception, whilst the "velocity line" must now conform to the direction of the track, and be thereby influenced to such an extent that it loses its identity. As we shall see later, this discrimination between the "velocity line" and such a line conforming with the direction of rails is of considerable importance.

The third definition which the author finds it necessary to employ is that of the "momentum line." This scarcely needs any explanation.

"The 'momentum line' is the line which any part or parts of a vehicle would follow if suddenly freed from all connection with, and consequently influence of, the track, whether the track is a plane surface or composed of rails. The part of the vehicle taken, unless otherwise defined, is a point at the centre of gravity of the mass of the complete vehicle."—(Definition 3.)

"The 'axis' of a car is a longitudinal centre line passing through the centre of gravity of a complete car."—(Definition 4.)

"The 'cross axis' is a transverse line passing through the centre of gravity of the car in the same horizontal plane as the axis."—(Definition 5.)

"The 'vertical axis' is the vertical line at right angles to the axis and to the cross axis passing through the centre of gravity of the complete car."—(Definition 6.)

The Track.

Within the confines of this paper we shall find it sufficient to consider straight track only of the ordinary construction employed for main line or street railways, comprising a pair of steel rails suitably supported and retained as accurately as possible to gauge and line.

In considering the influence of this straight track upon the masses which it is designed to support and direct, it must be remarked that, in order to obtain maximum economy, all masses should move in a perfectly uniform line, quite free from minor irregularities, and on a straight track the most uniform line possible will obviously be a mathematically straight line.

Now a mathematically straight track is not practicable any more than a mathematical plane surface, so that, relatively to the ideal uniform line of motion which a carriage upon rails should follow, the most perfect track is irregular, each rail varying vertically and horizontally from the ideal line, from its mate rail, and consequently in gauge.

Before considering further the characteristics of railed track, there are two considerations relating to direction which must be particularly noted, and these are:—

The property of direction in the track.

The property of direction in the moving vehicle.

All vehicles running upon rails, as hitherto employed in practice, depend upon gravitation for the fact that they, or rather their wheels, are kept downwards upon the face of the track; consequently the wheels follow in the vertical plane direction the irregularities of the rails.

To summarise direction in the track, it is sufficient to consider, in addition to the vertical direction, the horizontal direction of the track—that is to say, the location and direction of the track relatively to the points of the compass, including changes of direction such as curves.

We will now turn our attention to "direction" as applied to a carriage.

A carriage, having mass and velocity, if its movement is considered as being quite independent of the influence of the support or *direction* of a track, it will tend to move in a mathematically straight line, unless acted upon by forces causing its path to become curved.

In the abstract it serves a useful purpose to consider the movement of a vehicle in a sense analogous to the movement of a projectile, and when we do consider the movement of a vehicle in this manner, since it is a vehicle, we assume that there is no rotation about its axis, or any peculiar movement to which a vehicle as such would not be subjected. Nevertheless, within these limits we can consider the movement and tendencies of such a vehicle without any regard to its actual direction in space, for we know that such a movement presupposes the property of direction, and thus the author hopes that he has made clear exactly what he means by direction in a vehicle as distinct from direction in a track.

Speaking broadly we may allude to *direction* of track as a *definite direction*, ascertained and settled when the track is constructed; while of a vehicle *wandering direction* suggests an important contrast, it being one of the prime functions of a track to compel *direction* of vehicle to a path in conformity with its own direction—*direction of track*.

It might well be stated, then, that the first function of a track is to *bring the direction* of a vehicle in conformity with its own *direction*. But this is not sufficient. The track, which is inherently irregular, must support and influence the progress of a vehicle having always a natural tendency to move in a uniform straight line, and must cause that

straight line to conform to the *direction* of the track, but without disturbing its uniformity by the communication of its own irregularities.

The Conformity Line.

"The 'conformity line' is the most perfect path a car running on a given track could follow. For convenience the 'conformity line' may be taken as that generated by any point or points lying in a longitudinal axis passing through the centre of gravity of a complete car."—(Definition 7.)

Before proceeding further there is one important consideration relating to the influence of the track upon each vehicle which we must introduce and limit by definition. Although the title of this paper would indicate that this enquiry is limited to the influence of track upon vehicle, it will, of course, be borne in mind that every action of the track is the complement of action or reaction in the vehicle. The perpetual reference to a mathematical line, since we are dealing with masses in motion, has already been justified clearly in the foregoing; but to those to whom the practical straightness of the best existing track would seem all-sufficient for practical purposes, a word concerning the distortion of track may prove convincing.

Vertical depression, whether little or great, always results under the weight of one or more of the wheels, the track returning more or less to its normal height after the wheel has passed on. This fact alone upsets the comfortable fallacy that the straightness of good track is "good enough." Transverse distortion of rails also occurs perpetually, although not with the same regularity and degree of uniformity as vertical distortion. When no carriage is present we can actually plot between two rails a central "track line."

A straight-edge across the two rails carefully bi-sected from the inner effective faces of each rail will give us an actual centre of track at that point, and this, repeated with a number of straight-edges at close, regular intervals, will give a series of points, a line plotted through which we will call the "apparent track line."

Although this line is easily ascertained in practice, we must be careful to note that, when a vehicle is present, each rail (and consequently this "apparent track line") becomes distorted, and since our real interest in the nature of track is when the vehicle is present, we must consider this distorted, or "virtual track line."

"The 'apparent track line' is that plotted through a series of points each at the transverse centre and average

level of the two rails of the track at that point."—(Definition 8.)

"The 'virtual track line' is the 'apparent track line' as affected at the instant when a vehicle is supported by that portion of the track."—(Definition 9.)

Direction in the track (*definite direction*, as we have styled it) is now reduced from a broad property and defined as the "virtual track line." Usually it will be sufficient to speak of the "track line," and only on occasion to discriminate between the apparent and the virtual.

Again, owing to the extension or compression of springs, we may have at a given instant a height or dimension from the car centre to the "virtual track line," which would not be the same, for the same load and vehicle, when the vehicle was standing still, or before or after the particular instant taken.

It has been shown that the "virtual track line" is not mathematically uniform. Even were it possible to insure, in practice, that the axis of a vehicle should follow a line parallel to the "track line," or, rather, did the resources of engineering science compel us to follow the "track line," vibration could never be eliminated, and, therefore, a passenger could never be *unaware of the fact that he was travelling*. At this stage let us bring our imagination into play, and, having in mind the striking exhilaration produced by the sensation of normal uniform movement, at speeds approaching 40 miles an hour, in machines moving through the air, quite independent of the disturbances common to vehicles on rails, *let us try to realise what a pure uniform line of motion of a vehicle over rails would mean.* Obviously, if the speed and direction were uniform, and the passenger suitably enclosed, no sensation would be communicated to his person which would intimate to him in the slightest degree that he was travelling. Anyone possessing imagination in a moderate degree, and a knowledge of elementary physical science, will at once perceive the importance of the practical attainment, if possible, of such a line of transition. The science of the subject of the movements of vehicles upon rails (which these definitions establish in place of the chaos which has hitherto existed) will, the Author hopes, and firmly believes, have the immediate effect of rendering traction upon rails along a line of movement so much more uniform and perfect than the "track line" that fatigue, invariably caused by rail travel of to-day, will become a thing of the past.

Owing to gauge clearance, track irregularity, trans-

verse and vertical elasticity in vehicle underframes, and the incidence and coincidence of any or all of these influences, we are not conveyed to-day along the "track line," but along an ever varying product of these tendencies, the "chance line."

"The 'chance line' is the line actually generated by the centre of gravity of a given vehicle over a given track."—(Definition 10.)

It ought to be remarked here that for convenience in practical work, carriages running comparatively near to the "track line" might be said to follow the "track line," or simply to follow the track, although they may not do so absolutely; and, again, it is convenient to speak of a carriage, which may be so disturbed as to make a line much more irregular than the "track line," as following the "chance line"; and, finally, it is convenient to speak of carriages moving with practically perfect uniformity as following the "conformity line."

The problem of ensuring that each carriage shall be so free from the influence of the track, that any point on the carriage shall make on all portions of the track, with regularity and certainty, the most perfect line or path over that track, is one of the most difficult that engineers or inventors have been called upon to solve. Of such vast industrial importance is the solution of this problem, on account of the economy it represents, that the author's labours will have been more than repaid, if, by this paper, he succeeds in directing attention to such a problem, whether its solution shall be arrived at by the aid of his definitions or otherwise.

The paper is accompanied by two appendices:—No. 1, Warner Lines; No. 2, Three Figures illustrating the definitions employed.

APPENDICES.

No. 1.—WARNER LINES.

An Original Method of Recording the Riding Qualities of Tramcars.

Classing together railway and tramway trains and horse-drawn tramcars, the unit carriages of which may be styled trailers, and considering independently single self-propelled units (such as a locomotive, rail auto-car, or electric tramcar), important differentia present themselves, the significance of which appears to have been overlooked in the evolution of the electrically propelled tramcar.

It may be taken as an axiom that the steering effect and general behaviour of any vehicle will vary according as it is drawn—(*a*) from some vehicle ahead, (*b*) by self-propulsion from a point which may be taken at the centre of its length, or (*c*) by either of the foregoing methods, while the vehicle is retarded by a rearward tractive force, as in towing one or more vehicles.

An example of the behaviour of a self-propelled unit is the small tank engine employed for shunting work and local passenger service. Such a locomotive, when hauled by another, is almost entirely free from the alarming side sway, characteristic of its action when not attached to another unit.

The consideration of electric tramcars as independent units, as distinguished from attached units, is extremely important as affecting fundamental principles of traction. Given a line of tramway track over which it is desired to transport cars and passengers from "A" to "B," it will be evident that the most efficient and comfortable result is obtained when the line of transition varies as little as possible from a dead-straight line between these points. To this line, as modified by conditions of street layout, etc., the writer has given the name of "conformity line." The nearer the body of an electric tramcar follows this "conformity line," the greater the riding comfort, and the less work expended in performing the transition.

For some time past the author has spent a considerable amount of thought on devising a method of registering the comparative variation of various forms of cars from this ideal line. Devices of the pendulum and gyroscopic order do not, for various reasons, appear to be of any use, but the following method has the great merit of simplicity and

ready application, and is one which the author believes to be not only novel, but of such a practicable nature which will probably ensure its acceptance by tramway managers and car makers as a criterion.

The principle employed is the Chinese plumb-line. A small reservoir containing water, coloured with whitening or any suitable paint, is securely fastened at the extreme front or rear of the car to be tested. Connected to this reservoir a fine spout is arranged so as to direct what is known as an anti-splash stream on to the track a short distance from the car. A line would thus be painted on the track, which will either be exactly parallel to the "conformity line," or will vary from it, and this variation, which may be exaggerated according as the stream is vertical or thrown forward, records the riding or comparative riding of one or more cars. This stream is controlled by a small cock.

On many systems where cars suspended on various forms of trucks are in use, complaints are frequently received from passengers as to the riding of particular cars. By this method lines can be painted side by side from one car of each type, both on straight track and round curves, and photographs taken before the paint lines have become effaced by traffic. The importance of this form of record will be evident when it is remembered that the oscillation of cars is frequently the resultant of forces producing side sway, and much less due to variations in track level than is generally supposed.

It must be remembered that the main function of a track is to form a supporting path for the rolling of the car, and that the levelness of track is almost perfect in practice. In the secondary function of steering, in which track construction has reached its limits, the tramcar should be allowed to follow the conformity line in preference to the track deviations.

If the riding of its cars is the general criterion by which a tramway system is to be gauged, then whatever the condition of track or style of cars on that system, photographs showing good lines will give the record. In order to make these records comparable, a standard inclination, size and height of nozzle, speed of car and paint mixture will necessarily have to be adhered to.

No. 2.—THREE FIGURES ILLUSTRATING THE DEFINITIONS EMPLOYED.

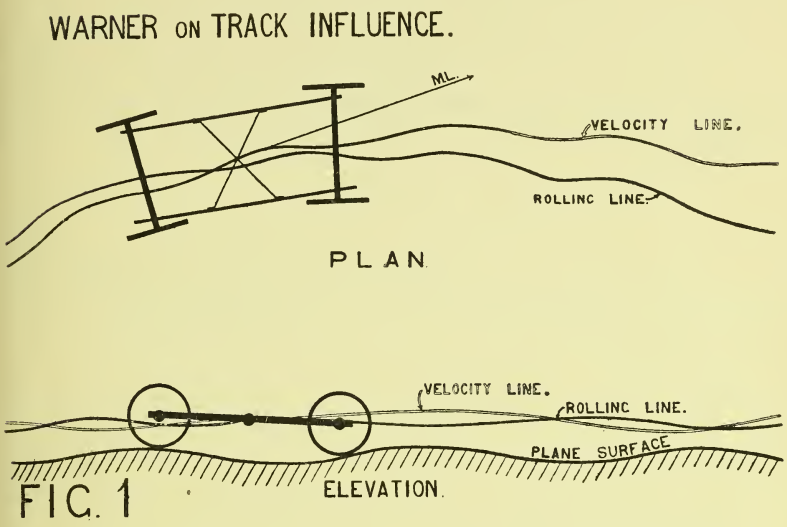


Fig. 1.—Illustrates the definitions dealing with the tendencies of vehicles over plane surfaces.

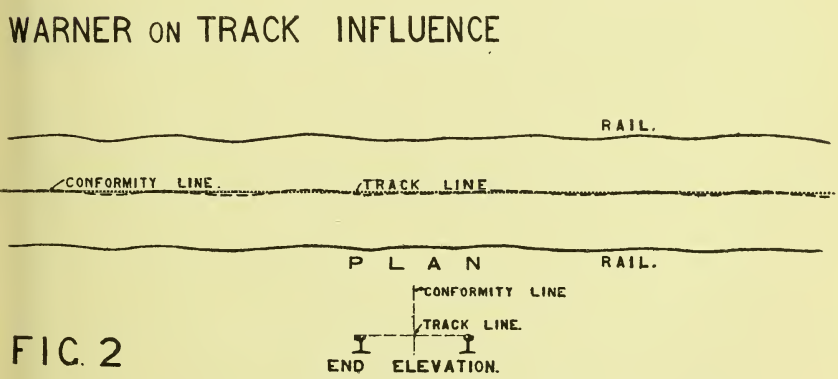


Fig. 2.—Illustrating the relative positions and character of the "track line" - - - - - and "conformity line" .....

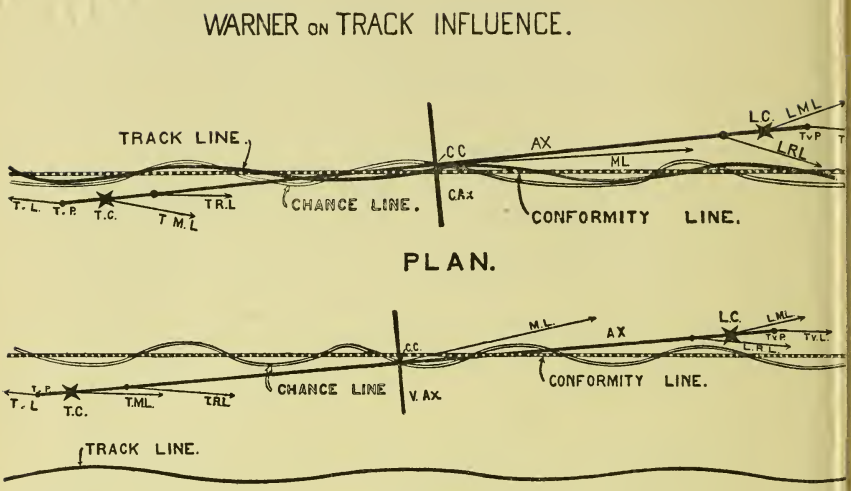


FIG. 3.

Fig. 3.—Illustrates the definitions relating to the influences controlling the relation and uniformity of the movement of a carriage upon rails.

SPECIFICATIONS FOR ENGINEERING WORKS.

By H. Laurence Butler, M.J.Inst.E., M.R.S.I.

[Read on Thursday, January 7th, 1909.]

The preparation of a specification, as a preliminary to entering upon a contract for engineering works, is unquestionably one of the most important of an engineer's duties, requiring very complete experience and thorough technical knowledge for its satisfactory accomplishment; yet some specification writers display a fine disregard of the true function of such a document, and show a child-like faith in the ability and generosity of the contractor, which, although very flattering to him, does not say much for the business instinct of its professors.

In this paper some of the points that are essential to the production of a specification which shall properly fulfil its purpose are touched upon, and this purpose is to amplify the contract drawings by giving detailed descriptions of the materials to be used, the methods of preparing and using them, and other information which cannot be conveniently written on the drawings themselves. The two main divisions of an ordinary specification are the Conditions of Contract and the Specification, properly so-called. The Form of Tender is not infrequently attached.

The Conditions of Contract, as their name implies, form the legal part of the document, as distinct from the technical description of work to be done, but it cannot be too clearly borne in mind that the *whole* of a specification, when duly signed by the parties to the contract, is a legal document which must be produced in Court if a dispute should unfortunately arise with reference to the works; and it is, therefore, of the utmost importance that it should be lucidly written in simple language, the clauses being arranged in logical sequence, and the descriptions exact and complete without being needlessly verbose. Every item of work should be allotted a separate clause, for when a single clause includes descriptions of several different matters confusion must ensue.

A complete alphabetical index, with the clause and page numbers attached, will be found to be (especially in the case of a lengthy specification) a great help in quickly finding any required subject, and cross references may sometimes be introduced with advantage.

Brevity, so far as it is consistent with completeness, being the hall mark of a good specification, no information should be introduced which may be clearly obtained from the drawings, the intention being that the drawings and specification are to be taken together, and a clause to this effect is sometimes inserted. On the other hand, it is waste of labour, besides being confusing, to put descriptive matter on the drawings which would be better included in the specification; and a mistake which is frequently made is to duplicate information in this way, obscuring the drawings with unnecessary writing, and overloading the specification with identical information.

A very common fault in specifications is indefiniteness of description, and this generally arises from the writer not having a clear notion of the work or materials which he attempts to describe, though in some cases it is due to the obscurity of the language, or to the misuse of certain words, especially "proper" and "sufficient." The engineer should know what is proper and sufficient, and should describe it in precise terms, otherwise he is only opening the way for trouble when it becomes necessary to find the meaning of these words in terms of actual materials and workmanship. The word "etcetera" should be rigidly excluded, and the matters covered by it clearly defined.

It should be hardly necessary to say that the drawings must be completed and inked in before the specification is written, or at all events before it is finally completed, as any other procedure will almost inevitably lead to more or less important omissions, with the result that "extras" will be writ large in the contractor's little bill. It is an advantage, when time permits, to have the detail drawings (if any) completed at this stage, as it is not unusual for important modifications to be found necessary when the details are got out on a larger scale. The drawings should, of course, be numbered, dated, initialled by the draughtsman, and signed by the engineer; and it may sometimes be useful to have reference letters or numbers on certain portions of the drawings, which may be alluded to in the specification.

An inexperienced writer of specifications is very apt to be uneven in his description of the work, writing with

unnecessary verbiage on those matters with which he is familiar, and dismissing some equally important point with a brief direction that "the work shall be done to the satisfaction of the engineer." A general direction of this kind usually implies that the engineer does not know what he wants, and therefore leaves the matter to the superior knowledge of the contractor—an attitude not very creditable to the former.

The only really legitimate use of this phrase is in a general clause referring to the whole of the works. An example of uneven description within the knowledge of the author exists in the specification for certain works of sewerage, in which the tests for Portland cement occupy a half-page of closely printed foolscap. None of the tests was applied, and apparently they were not intended to be applied, but the whole description was taken *en bloc* from another specification, presumably with a view to overawing the contractor. In the same specification the description of some pumping machinery at the disposal works appears to have been copied direct from the estimate of a firm of mechanical engineers, only the prices having been left out, and the curious commercial brevity of the phraseology, comprising such phrases as "including all necessary fittings complete," stands out in striking relief from the rest of the document.

It is evident, then, that one of the most essential qualifications for a specification writer is a thorough knowledge of his subject, and he should have also a sufficient command of the English language to enable him to express his meaning clearly and tersely. It is quite unnecessary to indulge in legal jargon and high-sounding phrases which the writer possibly does not understand, and it is by no means a fault to repeat words again and again if they express the meaning of the writer more clearly and forcibly than an alternative phrase would do. A specification is seldom judged by literary standards of excellence.

It is also necessary that the specification writer should have a thorough knowledge of trade customs, such as discounts (in order to define "prime cost"), the methods of measuring timber and scantlings, the different modes of dressing masonry work, whether the word "best" applied to certain materials will really mean best, or if by trade custom it may be taken to mean an inferior quality. Moreover, in the case of structural work, he should make himself acquainted with the regulations in force in the district in which the building is to be erected, and should

make it clear in the specification if the contractor is to take the responsibility of complying with the local authority's requirements or otherwise.

Another error which may occur through inexperience is that of specifying impracticable sizes of materials, such as timber and metals, and this may also occur when clauses are copied from obsolete or badly written specifications. The method of compiling a specification on the "scissors and paste" principle, by taking clauses from old specifications, is one that will lead an inexperienced writer into error more quickly than any other, because if he has any doubts as to the reliability of the description, it will be more or less discounted in his mind by the fact that that particular clause has been used before, regardless of when or under what circumstances it was used.

The degree of detail which a specification should contain is governed very largely by the magnitude and importance of the work, as it is obvious that the detail in the specification for a £50,000 contract would be merely a display of misdirected energy if applied to the specification of works costing, say, £500.

A practice which should be studiously avoided wherever possible is the specifying of alternative workmanship and materials. It is far better to be exact in defining what is to be done or supplied, because it then affords no ground for dispute or difference of opinion. However, with regard to the actual methods of carrying out the work, the contractor should not be tied to any particular means of effecting the required end, unless special circumstances require it, for, provided the materials and workmanship are satisfactory, it is better to allow the contractor to use his own discretion as to the manner of producing the required result.

The arrangement of a specification is generally as follows:—

(1) Conditions of contract and general regulations applying to the whole of the works.

(2) *General* description of materials and workmanship, excluding purely local or particular directions.

(3) Detailed description of the various portions of the work, systematically arranged.

The Conditions of Contract usually begin with a definition clause, which, in order to obviate needless repetition, defines such words as "employer," "engineer," "contractor," "prime cost," and similar matters. Other clauses enumerate the conditions to be observed in carrying out the works, and make the contractor responsible for giving

notices required by the Local Authority, require him to sign the drawings and specifications within a given time from the acceptance of his tender, to provide sureties for the satisfactory completion of the work, and to commence the work within a stated period after receiving notice from the engineer to do so.

A very useful clause is that empowering the engineer to vary or alter any part of the works without vitiating the contract, and a clause requiring the contractor to render weekly accounts in writing of all omissions, extras, and variations, greatly assists the engineer in deciding what payments may be made from time to time on account of work done, as well as in the final adjustment of accounts.

Other clauses may refer to the method of ascertaining prices for extra works, the power of the engineer to take samples for testing purposes, the opening up of work for inspection, the prohibition of assignment or subletting of the contract, responsibility for accidents, time for completion, period of maintenance, suspension of works through various causes, mode of payment, engineer's certificate of completion, and other matters of this nature, the conditions usually concluding with a clause providing that all disputes may be referred to an arbitrator for settlement.

It is not unusual, however, to have, in place of the arbitration clause, a condition that the engineer shall have the exclusive right to authoritatively determine the meaning of the contract. Such a provision is, perhaps, rather unsatisfactory from the standpoint of the contractor, who may be inclined to consider the engineer unsuitable to act in this capacity, by reason of the fact that the latter has generally formed an opinion on any dispute which may arise before the matter is referred to him for settlement; but unless it could be demonstrated that the engineer's opinion was not open to argument or reconsideration, or that he had deliberately shown prejudice or partiality, the Courts could scarcely be persuaded to declare that he was unfit to be arbitrator. The chief advantage of the clause, from the engineer's point of view, is that it supplies a summary means of remedying the faults and supplying the omissions in a badly drafted specification. It would appear that the arrangement most satisfactory to all parties is for the engineer to have the final decision as regards workmanship and materials, and to provide for appeal to an external arbitrator on all matters relating to payment, such as the amount of extra works, loss to the contractor through delay or alteration of the works, and similar questions. A further modification of this provides that

no appeal to an outside arbitrator shall be made during the progress of the works, but that disputes on any matter arising out of the contract shall be temporarily decided by the engineer, and his decision shall be binding on all parties until the completion of the works, after which the matter (unless explicitly reserved for the final and binding decision of engineer, without appeal) may be brought before a referee. This arrangement is designed to prevent any disputed matters from causing delay in the execution of the works.

In alluding to the drawings, it is a good plan to add a paragraph to the effect that figured sizes are to be followed in preference to the scale dimensions, except in cases of obvious clerical error. The clauses enumerated above do not by any means exhaust the list of provisions that it may be necessary to make in the case of a large contract, and in very small works some of the clauses may be reasonably omitted, but they are mentioned as being generally applicable to contracts of moderate size.

The specification proper usually begins with a description of the site of the works, specifying any unusual features which may exist ; and if the site is very inaccessible, involving a great deal of haulage work, it is an excellent thing to provide a key plan, showing the distance from the nearest station, and marking on it any unusually steep hills, bad roads, or other circumstances likely to affect the cost, although some engineers prefer to let the contractor find out all these things for himself, and insert a clause in the conditions to the effect that "the engineer cannot be held responsible for any incorrect information supplied."

The next clause generally enumerates the drawings, giving the number and title of each one, with the words, "and such further detail drawings as may be supplied by the engineer to the contractor from time to time." Then follows the description of materials and workmanship applying to the whole of the works, and including such matters as cement, sand, mortar, concrete, bricks, brickwork and the like, leaving the particular description of the individual parts of the work to be dealt with later.

The general description may conveniently conclude with a clause requiring the contractor, before commencing the work, to deposit with the engineer a sample of each kind of material intended to be used, all materials employed in the execution of the works to be equal in quality to the samples so deposited.

The remainder of the specification consists of detailed

descriptions of the different parts of the work, subdivided under general headings. For instance, in the case of a new road and sewer, the first part would be headed "Sewers and Manholes," and the first clause would deal with "Excavation," followed successively by "Timbering," "Filling in," "Concrete Pipe Laying," "Brickwork, "Manhole Covers," and so on. The next general heading would be "Roads," and the headings of the clauses would follow some such order as "Excavation," "Foundations," "Hard Core," "Kerbing and Channelling," "Metalling," "Grouting and Rolling," "Footpaths," etc.

A systematic arrangement of this nature tends to exclude the probability of any serious omission, and assists any subsequent reference to the specification. Printing a brief note of the contents of each clause on the margin of the page is a convenience when it is desired to refer to any particular item, but it should be made clear that these marginal notes are merely auxiliaries, and do not form part of the specification any more than the index does.

Another arrangement is to divide the work up under the headings of various trades, such as "Excavator," "Bricklayer," and so forth, the general description of materials preceding the detailed enumeration of particular items under the heading of the appropriate trade. This method, however, is usually applied only to specifications for building works.

Some engineers and architects advocate the free use of marginal sketches to further elucidate the intention of the written description, but where the specification is printed this method is inapplicable, owing to the extra expense involved in printing, and in any case it is doubtful whether such details would not be better demonstrated on the drawings. A competent specification writer should be able to describe his meaning with sufficient clearness to enable him to dispense with such a superabundance of illustrations. In the case of any very complicated piece of work, a detail drawing to scale is obviously of more utility than a mere sketch, and in simpler cases a written description should be all that is required.

Trade catalogues form one of the most useful items in the specification writer's stock-in-trade, and here again the advantage of system will be apparent. A complete set of trade catalogues filed on the decimal system, and accompanied by a card index in two divisions, one of subjects and the other of names of firms, will enable the engineer to turn up at the shortest notice the information with regard to any manufactured article that he may

require, and to make a comparison between the manufactures of different firms, with a view to finding the particular article best suited to his purpose.

In this connection it may be said that the practice of specifying that certain articles shall be supplied by a particular firm is one that should not be carried to excess. It is not an unheard of thing for a manufacturer, who has been specified to supply certain goods, to raise his prices for the occasion, but if estimates are obtained from firms of equal standing and reputation, it is generally possible to obtain a lower price than if the other course were adopted. The selection of one firm to the exclusion of all others may also suggest unfairness on the part of the engineer, and may create the idea that his selection is not without profit to himself, although it is to the credit of the profession and the manufacturers that cases of bribery are so extremely rare as to be practically non-existent. It may here be remarked that a good commercial knowledge (including the ability to price out roughly the present market value of any ordinary materials and labour) is a distinct advantage to a specification writer, enabling him when selecting goods to thread his way through the maze of trade discounts, discounts for cash, and special discounts for large quantities with which some merchants conceal the actual cash price of their manufactures, especially as in some cases it is not unlikely that he may be called upon for advice upon particular items when the settlement of accounts takes place.

A matter which too seldom receives thorough consideration is the question of what part (if any) of the materials for the works can be obtained locally. The practice of specifying goods which must necessarily be conveyed long distances before they can be utilized, while equally satisfactory materials can be procured near the site of the works, argues negligence on the part of those responsible for drafting the specification, and is usually due to culpable ignorance of local conditions. As illustrating this point, a case may be mentioned where a contract was secured at abnormally low prices, the contractor making a good profit by utilizing the sand and gravel obtained from the excavations, which other less wideawake contractors had counted upon having to bring several miles by road. In this instance it was even hinted that the contractor went to the extent of carting away alleged "surplus material" from the site, which he afterwards turned to his own use and profit.

Although the preparation of bills of quantities does not

form part of the work of writing a specification, it may not be out of place to mention that attempts have been made in the past to combine the two documents in one, but as each has an independent function, any attempted combination must be unsatisfactory. The Bills of Quantities are merely schedules of labour and materials, arranged so that prices may be conveniently attached, and the endeavour to make them serve another purpose is inevitably foredoomed to failure. Moreover, if the quantities are made a part of or annexed to the contract, and any dispute should arise, the Court may hold that the contract on the builder's part was not to complete the works, but only to execute the quantities.

It is not possible, within the limits of this paper, to touch upon all the points which may arise in connection with preparing a specification, yet enough has been said to demonstrate that specification writing is worthy to rank high amongst other more showy, but scarcely more interesting, professional work ; indeed, it requires for its satisfactory accomplishment a high degree of technical knowledge, besides something more than a smattering of legal information and (what engineers too often lack) a sound commercial training. If, in addition to these qualifications, the specification writer possesses plenty of sound common sense, allied to practical experience in his work, he will be well fitted to assist in dispelling the much too popular fallacy that the preparation of specifications for engineering works is a necessary but uninteresting piece of drudgery, carrying with it no reward but that which always accompanies work well done.

Some useful works of reference on this subject are :—

Specifications in Detail. F. W. Macey (Spon). 21s.
Building Specifications. John Leaning (Batsford). 18s.
Conditions of Contract issued by the R.I.B.A. (published in Laxton's and other Price Books). 1s.
"Specification," published annually (Technical Journals, Ltd.). 2s. 6d.
Municipal Engineer's Specification (Technical Journals, Ltd.). 2s. 6d.

THE STABILITY OF ARCHES.

By Henry Adams, M.Inst.C.E., etc., Past President.

[Read on Thursday, February 4th, 1909.]

In its more evident aspect an arch is an assemblage of tapered blocks forming a curved structure over an opening, supporting its own weight and generally some load above. It is essential that the abutments should be rigid, and it will then be found that many structures furnish real arches that would not at first sight be suspected of so doing. It is not necessary that an arch should be made up of separate voussoirs or wedge-blocks; it may be formed of half-brick rings, or may be of homogeneous concrete. Whatever be the construction it may be divided up into real or imaginary portions, each of which must be in equilibrium under the various forces acting upon it. To clear the way, Fig. 1 shows in one view all the common terms used in connection with arches. Then Fig. 2 shows the forces acting on a voussoir in one of the haunches. Working downwards from the centre the voussoir is subject to a direct thrust which is in process of transmission to the abutment; then it has its own weight and the superincumbent load acting vertically downwards. Combining these two forces in a parallelogram the diagonal gives the resultant, and equal and opposite to this is produced the reaction or equilibrant, which forms the thrust for the next voussoir below. There are two other conditions which must now be fulfilled; the amount of thrust must be within the resisting capacity of the material to compression, and the angle of thrust must be within the limiting angle of resistance to friction. When the thrust is central at the joint the stress is uniformly distributed, and is merely the thrust divided by the sectional area $\frac{W}{A}$; but when the thrust is not through the centre a bending moment is developed, which increases the stress on one side and reduces it on the other, the complete formula then being $\frac{W}{A} \pm \frac{M}{Z}$; where W = thrust in tons, A = area in square feet, M = bending moment in ton-feet, Z = section modulus in foot units.

The length of an arch is the distance through from face to face, and as the reasoning that applies to the whole arch applies to each foot length it is usual to take what may be called the thickness through the paper as 1ft. The remaining condition of stability, viz., that the angle made by the thrust with the joint must be within the limiting angle of resistance to friction, requires a little digression. Fig. 3 shows a rough block of material of weight w resting upon a horizontal surface. The force required to push it along will vary with the nature of the surface and the weight of the body—call it p—then constructing a parallelogram of forces, the angle made by the diagonal with the vertical will be the measure of the friction. This angle is called the "limiting angle of resistance," and its tangent, or tan ϕ, is called the coefficient of friction, and generally represented by the Greek letter μ. Now, if the plane upon which the body rests be tilted up to the angle ϕ, as in Fig. 4, the body will be just on the point of slipping, or in a condition of unstable equilibrium. When the line of thrust from a voussoir makes a greater angle with the joint than the angle ϕ, slipping will take place ; but as the coefficient of friction for mortar joints is about $\mu = 0.5 = \tan \phi$, ϕ would be, say, $26\frac{1}{2}$ degrees, and this can only happen in very extreme cases. Failures by crushing, or by opening under tension, are much more likely to occur. Fig. 5 shows a series of voussoirs with the forces acting upon them as described. The points where the thrusts cross the joints, shown by small circles, will, when connected by a continuous curve, give the "line of thrust" upon the arch. This is sometimes called the "curve of thrust," or "curve of equilibrium," or "Moseley's line of least resistance." It is shown in this figure as passing through the neutral axis of the voussoirs, but it is very seldom that the load can be so adjusted as to produce this result. When the load is concentrated chiefly towards the centre of the arch, the line of thrust will approximate to the stroke-and-dot curve shown in Fig. 6, causing a tendency to failure by crushing at the extrados at crown and intrados at haunches, and or tension at intrados at crown and extrados at haunches. If, on the other hand, the load is too great over the haunches, the reverse will take place, as shown by Fig. 7. There is another general principle involved which should be noticed before proceeding to the practical determination of the thrust in arches. It is shown in Fig. 8, where ABCD represents half an arch ring with superstructure. When any external load is carried, such as passing traffic,

it is usual to add it to the superstructure as equivalent material to produce the same load, as this simplifies the work of calculation. Then the whole load W, acting through its centre of gravity, has a leverage of y to the centre of the skewback, producing a moment of Wy. The clockwise motion of this piece is resisted by the thrust P from the other half arch acting at the centre of arch ring at crown with the leverage x, producing a moment of Px, so that $Px = Wy$, and therefore $P = \frac{Wy}{x}$, furnishing a means of discovering the thrust at the crown from the given conditions of arch and loading.

Formulæ for the determination of stress in arches (except the one already given) are of little value, as they are mostly based upon theoretical conditions, and the graphic method will be found much more suitable for practical use. The first operation will be to determine what may be called the primary thrusts, at the crown and the skewbacks, as shown in Fig. 9. For this purpose half the arch must be drawn down to scale, and the superincumbent loads shown to the same scale above the arch ring. Then the area of this figure must be determined by planimeter or equalising lines, and multiplied by the weight per cubic foot to arrive at the total load, then cut out and suspended from two points to find the centre of gravity. A vertical line is then drawn through the centre of gravity, a horizontal line from the middle of the arch ring at crown to meet it, and from the intersection a line to the middle of arch ring at skewback. The total load being set off on the vertical line below the intersection, the parallelogram may be completed, which will give the primary thrusts. The middle of the arch ring has been taken in each case so that the line of thrust may pass through those points, but it may happen that they are not the most suitable. If the line of thrust exactly followed the curve of the arch they would, of course, give the minimum stress ; but the shape of the line of thrust depends entirely upon the distribution of the load, and is independent of the shape of the arch provided to do the work. There are various possible lines of thrust for the same loading, according to the position taken for the two points through which the primary thrusts pass. Each point may be taken anywhere within the range of the middle third of the depth, or even slightly beyond ; but Nature chooses that line of thrust which will, on the whole, give the minimum stresses, and although we may endeavour to find it by trial we cannot always succeed. Fig. 10 shows an ordinary arch under

symmetrical loading. The primary thrusts having been obtained, as already described, and shown on one side of the arch, the other side is then divided into real or imaginary voussoirs, with vertical lines from the joints to show the portion of load upon each. The loads are then scaled off and measured down to a suitable scale on the vertical load line in Fig. 11. The horizontal thrust at crown of arch is marked from the bottom of the load line, and the inclined line to close the figure should then be exactly equal to the inclined thrust at skewback. Now draw vectors from the points on the load line to the bottom angle, and parallel with each of these draw the portions of the line of thrust on the arch across the respective divisions. Anyone with an elementary knowledge of graphic statics will observe that the line of thrust is part of a funicular polygon, and it will be seen now that if the ends are shifted the whole line may be made to take a position that will equalise the stress at those points where the line approaches nearest to the edges of the arch ring. In important cases it is necessary to make a calculation of the stress by the formula $\frac{W}{A} \pm \frac{M}{Z}$, as the thrust increases towards the abutments, and the line of thrust may therefore approach either edge at the crown with less risk than at any point lower down.

It is commonly supposed that as a semicircular arch has a horizontal bearing there will be no outward thrust, and only a vertical load upon the supports. This, of course, is wrong, as all practical conditions of loading give of necessity an outward thrust. Action and reaction are equal. The horizontal thrust at the crown gives rise to an equal horizontal thrust at each of the supports, although it may be disguised to some extent by increasing the vertical loading over the ends of the arch. Fig. 12 shows what is stated to be the proper depth of arch ring for either a semicircular or semi-elliptical arch ; more correctly it is the depth of material that, acting as load, will produce a line of thrust parallel to the soffit of the arch. It will be observed that the depth increases very rapidly towards the ends of the arch, and over the springing it would amount to infinity. Fig. 13 shows the same result approached in a different manner. The semicircular rib may be assumed to be replaced by a series of straight bars. Then force lines may be added to show the loads upon the bars requisite to maintain equilibrium in their given position, and the spaces numbered according to Bow's Notation. Then, in Fig. 14, the distance

12-x is taken as the permissible thrust at the crown, and vectors are drawn from 12 parallel to the bars across the numbered spaces, giving the points 2-10 on the vertical load line. Then any distance, such as 12-8 in Fig. 14, gives the thrust in bar 12-8 in Fig. 13. The loads 7-8, etc., in Fig. 14, are transferred to the force lines 7-8, etc., in Fig. 13, and give the curved black outline representing the required loading on the arch. The dotted line in Fig. 13 shows the effect of increasing the load, and the stroke-and-dot line shows by vertical ordinates from soffit the variation in the thrust. Of course, in practice no such loads towards the abutments are possible, and a semicircular arch is, therefore, a disadvantageous form of construction.

It will now be interesting to take the actual case of a semicircular arch which failed, and much instruction may be gained from the various points which the investigation will bring out. The arch was in one half-brick ring set in cement, with a span of 10ft., and the only load to be carried was the weight of the arch itself, which was to form the covering for a small reservoir. Before the centering was removed the arch bulged at the haunches, and when it was removed the arch collapsed. To search for the cause of the failure draw the half-arch, as in Fig. 15, divide up the arch ring into suitable blocks or voussoirs, and draw a vertical force line through the centre of gravity of each, number the spaces, and draw the load line in Fig. 16. Take a pole, as shown on the right, and draw vectors. Parallel with these draw the funicular polygon shown on the top of Fig. 15, draw the closing lines to intersect in the line of the mean centre of gravity of the loads. Draw the primary thrust lines, then on Fig. 16 draw 14-15, equal to the horizontal thrust, and 15-1, equal and parallel to the inclined thrust. Then join point 15 with the numbered points on the load line, and parallel to the lines so drawn construct the curve of thrust on Fig. 15. It is now clear why the arch failed ; the curve of thrust passes a long way inside it, causing it to bulge just as if there were a force thrusting up the haunches. The arches of railway viaducts are often semicircular, and an approaching load gives an unsymmetrical curve of thrust, which would tend very strongly to thrust up the further haunch if it were not for the fact of the spandrils being filled solid for a certain height, the filling being virtually an increase of thickness to the arch ring. In case there should be failure from any cause, a further precaution is observed by having a stop abutment at

every tenth arch, the intermediate piers being only sufficient to withstand the difference of thrust from two adjacent arches, while the stop abutment can take the whole thrust from an arch, or series of arches, with no counterbalancing thrust.

The load upon an arch in a brick wall is not a very easy matter to determine. When the width of opening is not more than about half the width of the wall, the effect of the bonding will be to relieve the opening from the weight of a considerable portion of the superstructure. This is evident from that fact that an opening may be made through an existing wall, as in Fig. 17, without any arch at all, the bonding being sufficient to support the material over the opening. If, therefore, an equilateral triangle be drawn above the ends of an arch, as in Fig. 18, the brickwork contained within that triangle, together with any portion of a floor or roof it supports, may be assumed to be carried by the arch, the weight of the remainder of the wall being transmitted by the bonding to the piers at the sides of the arch. There must naturally be a limit to this mode of working, and, in cases where the arch occupies a larger proportion of the width of wall than one half, it will be safer to consider the arch as carrying the whole of the brickwork vertically above it, as in Fig. 19. In either case, in considering the stability of the piers, the whole weight of the arch and brickwork above must be divided between the two piers, and the vertical force line in each combined with the horizontal thrust of the arch at the crown, or the thrust at the skewbacks, must be combined with such of the weight of the wall and piers as has not been taken upon the arch itself. The reason the opening through the brick wall of Fig. 17 remains stable is that a natural arch exists in the brickwork, which may be illustrated by two other forms. What is known as a square arch or gauged camber arch is not a true arch, but contains a virtual arch within its substance, as shown in Fig. 20. If the line of the skewbacks be produced to meet on the centre line of the arch, and a curve be drawn to pass through the top edge of the gauged bricks to meet the skewbacks, this will form the extrados of the virtual arch; and another curve, drawn from the same centre through the lower edges of the skewbacks, will give the intrados of the virtual arch.

A still more interesting case arises in connection with a concrete lintel, Fig. 21. If the abutments are rigid the lintel contains a virtual arch, the lower half of the lintel giving the rise, and the upper half the depth of arch.

This is all worked out fully on the large diagram, where it is shown that although an infinite number of virtual arches may be drawn, this one gives the maximum of supporting power, or, in other words, the induced stresses under a given load are found to be the minimum. If the abutments are not perfectly rigid the lintel is merely a rectangular beam, supported at the ends and subject to the usual stresses of its circumstances.

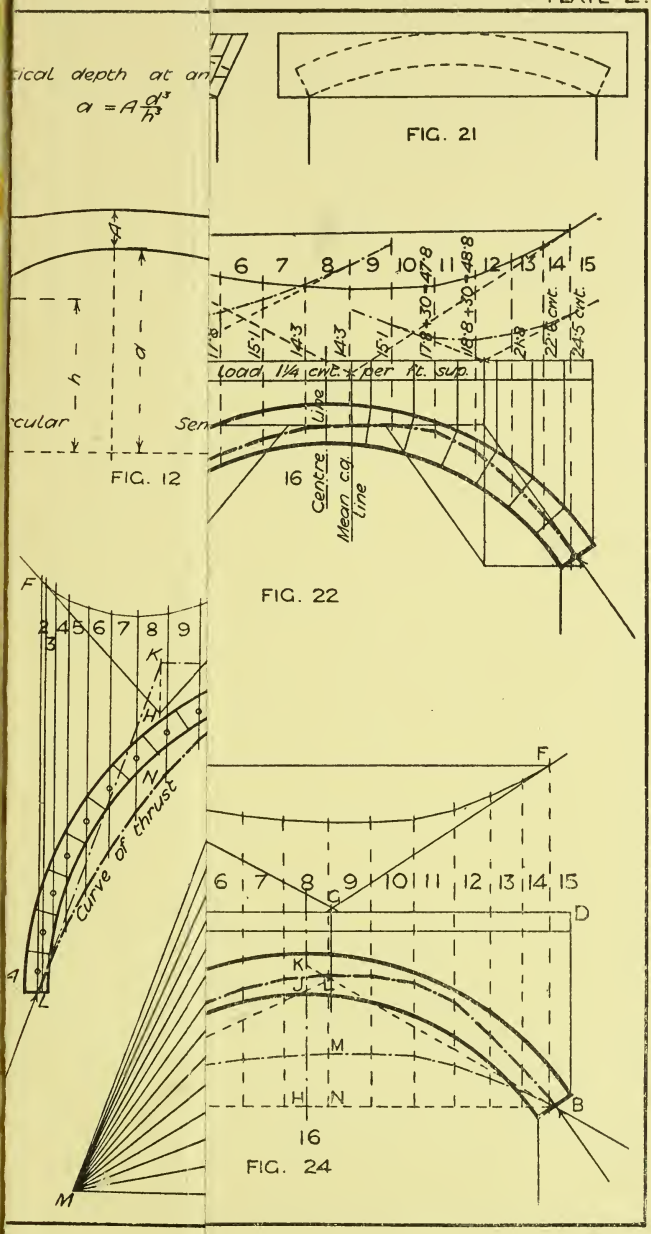
The effect of irregular loading upon an arch has now to be considered. The irregularity will generally arise from an advancing load, say a traction engine, and the transmission of the load from the surface of the ground to the extrados of the arch may be considered as spreading in wedge fashion at an angle of 60 degrees from the line of contact of the wheels. It is usual also to allow for a further live load of, say, $1\frac{1}{4}$ cwt. per foot super distributed over the whole surface. Fig. 22 shows an arch with structural load, external distributed live load, and concentrated live load, or rolling load taken at the worst point—*i.e.*, over one of the haunches. After dividing up the arch into the actual or assumed voussoirs, and finding the weight above each, the position of the vertical through the mean centre of gravity of all the loads, including the concentrated loads, should be found by funicular polygon as shown, and then the mean centre of gravity line for each half. The description given in connection with the semicircular arch will enable the method of constructing the reciprocal diagram, Fig. 23, to be readily understood.

It will be observed that the parallelograms for the primary thrusts are constructed with the horizontal lines passing through the middle of the arch ring on the mean centre of gravity line for the whole load, and when the curve of thrust is completed it will be found that it is not quite horizontal at this point, and that therefore there must be a slight error in the result ; but that this is not a serious matter can be shown by finding the curve of thrust on the same arch in another manner.

Draw out the arch and loads as before, and proceed as in Fig. 24. Set down the load line 1 to 15 in Fig. 25, and select any pole 0 ; draw vectors, and parallel to these construct the funicular polygon EFG ; then G will give the position of the mean centre of gravity line. From 0 draw 0-16*a* parallel to EF, giving the vertical reactions at the abutments 1-16*a* and 16*a*-15. Next, from B, the centre of the skewback, draw a horizontal line to meet a vertical line through the centre of the arch in H. From H set up HJ = 1-16*a*, and HK = 16*a*-15. Join AJ and BK, and if

produced they should intersect at L on the mean centre of gravity line. Then, in Fig. 25, draw 1-16 parallel to AL, and 15-16 parallel to BL, to obtain point 16. The remaining points on the load line are now drawn to point P, and the curve of thrust AMB constructed parallel to these lines. This does not pass through the arch at all, but, nevertheless, it is a true thrust curve, and only wants raising into its proper position by magnifying all its vertical ordinates, as follows:—Draw QR (Fig. 26) equal to MN (Fig. 24), and at any distance from QR set up a height ST equal to the distance from N to the centre of arch ring in Fig. 24. Join SQ and TR, and produce to meet in a point U. Then the ordinates to the curve AMB, being marked off on QR and lines drawn from the point V through the divisions on QR, will give the corresponding magnified ordinates on ST. These, being set off on the verticals of Fig. 24, will give the true curve of thrust.

In conclusion, the author regrets that, having only had a few days to prepare this paper, he has had to leave many interesting points untouched. Several diagrams showing the detailed construction of arches will be found on the walls which it was not thought necessary to reproduce in the paper, and the author will be happy to explain to the members any points upon which they may desire further information.


ical depth at an
$a = A\frac{a^3}{h^3}$
FIG. 21
A
a
h
cular
FIG. 12
6 7 8 9 10 11 12 13 14 15
load 1¼ cwt. per ft. sup.
Sen
16
Centre line
Mean c.g. line
FIG. 22
F
2 3 4 5 6 7 8 9
K
H
N
Curve of thrust
A
L
M
F
6 7 8 9 10 11 12 13 14 15
C
D
K
J
L
T
M
H
N
B
16
FIG. 24

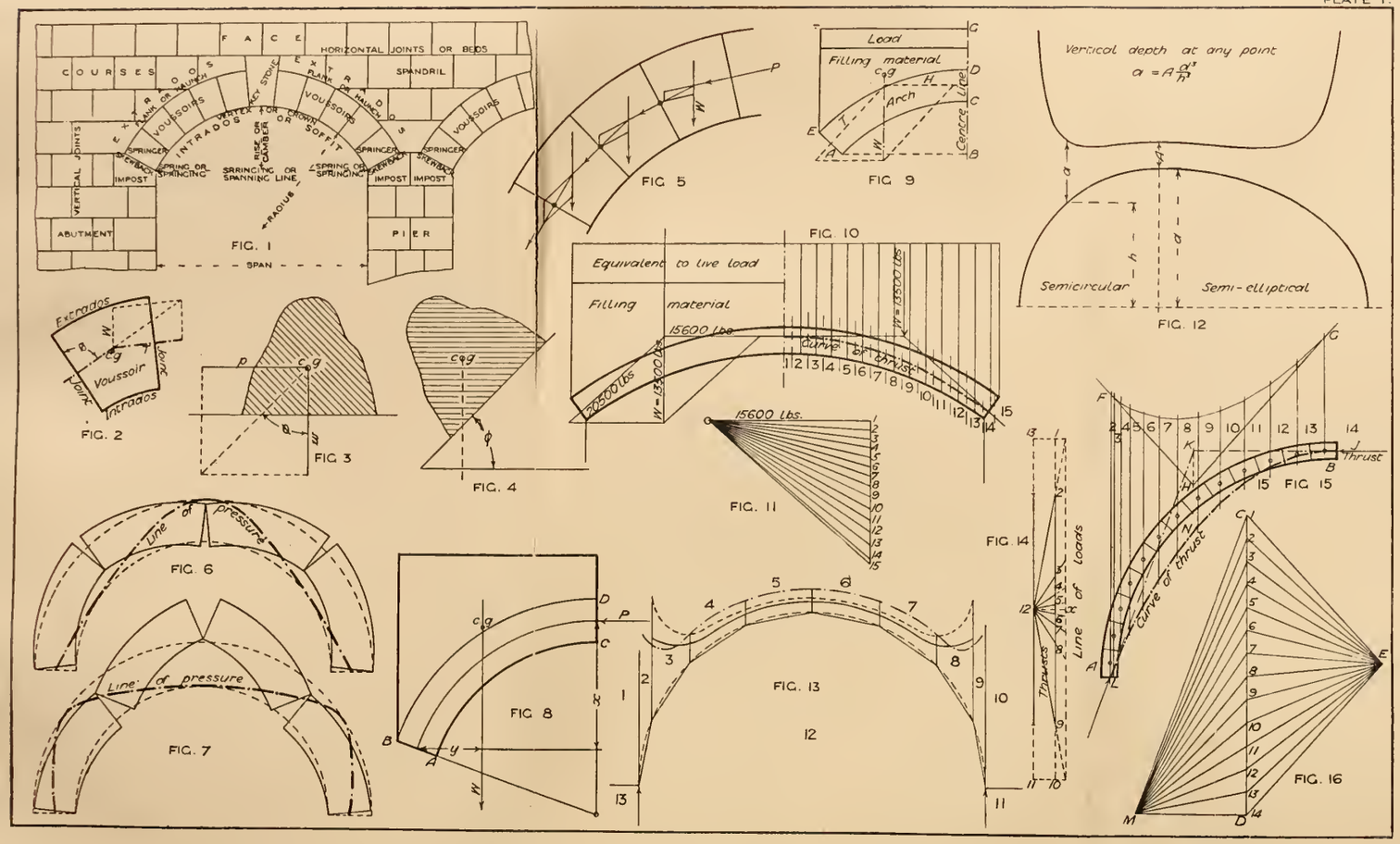


FIG. 1
FIG. 2
FIG. 3
FIG. 4
FIG. 5
FIG. 6
FIG. 7
FIG. 8
FIG. 9
FIG. 10
FIG. 11
FIG. 12
FIG. 13
FIG. 14
FIG. 15
FIG. 16
Semicircular
Semi-elliptical
Vertical depth at any point
Equivalent to live load
Filling material
15600 Lbs
Line of pressure
Curve of thrust
Line of loads
Thrust

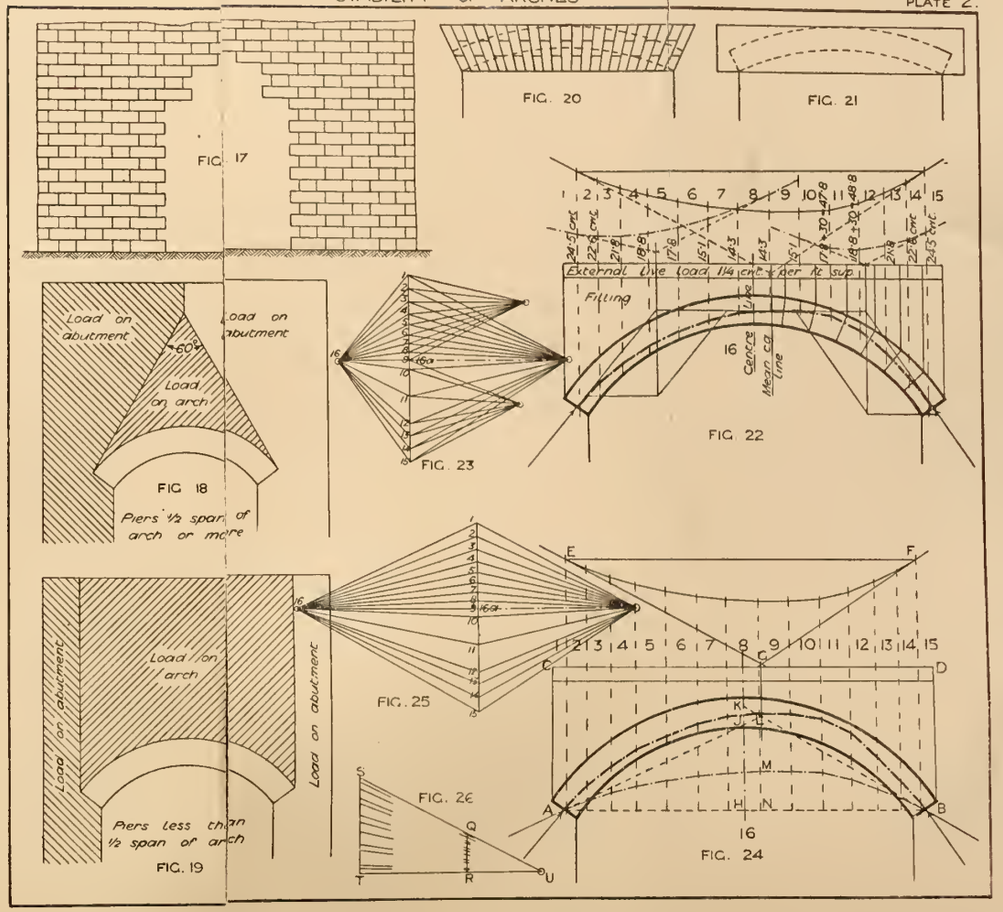


FIG. 17
FIG. 18
FIG. 19
FIG. 20
FIG. 21
FIG. 22
FIG. 23
FIG. 24
FIG. 25
FIG. 26
Load on abutment
Load on arch
Piers ½ span of arch or more
Piers less than ½ span of arch
External live load 114 cwt per ft sup
Filling
Centre line
Mean c.g. line

SOME COMMERCIAL ASPECTS OF THE MANAGEMENT OF CENTRAL ELECTRICITY SUPPLY STATIONS.

By R. Borlase Matthews, Wh. Ex., A.M.I.C.E., A.M.I.E.E.

[Read on Thursday, March 4th, 1909.]

The late Lord Kelvin once made a statement to the effect that he considered it in no way derogatory for any scientist to turn his attention to the details of practical applications of scientific knowledge, because of the great benefits to the public at large accruing from such a course. Similarly no apology need be made for the investigation of so practical a side of the great Science of Electricity as the proper development of Central Electricity Supply Undertakings to their utmost extent, for this is a matter of interest not merely to those responsible for the management of these concerns, but also directly to all interested in the electrical industry; for an increased demand for electrical energy opens out new fields of investigation, introduces new problems of great scientific interest, gives greater scope for inventive faculties, and at the same time provides the manufacturers with orders, engineers with greater opportunities of exercising their skill, and mechanics with more work.

There is a tendency in some quarters to say that the managers of Electricity Supply Stations have not done all that might have been done in the past to increase the number of their consumers. This may be so in some instances, but not on the whole, for none have done more towards bringing the whole industry to its present advanced stage than that section of the electrical profession connected with the business of electricity supply. Pioneers, while grappling with the mass of technical problems and difficulties associated with the operation of an electrical plant in its earlier stages of development, had an equally, if not more onerous task, in persuading a very indifferent and incredulous public to adopt a system of lighting, heating and power, which was a radical change from anything to which it had hitherto been accustomed. This

path was not made any easier by the faulty and ill-designed lamps and other apparatus that the consumer had available for use.

As Colonel Crompton said, when speaking on this subject at a meeting of the Institution of Electrical Engineers last year, "It is not sufficiently realised by the general public, and even in this Institution, what great efforts have been made in the past to improve the load factor, and I am sorry to say with disappointing results."

Now, while the electrical industry has progressed by leaps and bounds, the customs and habits of the general public have also greatly advanced and changed. People of to-day demand a higher standard of luxury than they did even a few years ago. They are better educated, they read and travel more, they are more restless, more difficult to impress, and at the same time they are, in a sense, more lazy.

People's attention is to-day claimed in every direction by up-to-date advertising, and therefore only that which is specially striking and stands out above the mediocre, can make any successful appeal. Hence the manner and method adopted to bring people to an appreciation of the many advantages of electricity must be considerably modified, to suit present-day customs and habits.

While the main principles of methods formerly in force are maintained, they need now to be clothed in such a guise as to present entirely new and more attractive features. A changed public living under conditions of greater stress and competition must be appealed to in a brighter and more forceful manner than formerly sufficed. This means that most careful attention will have to be given to details, the consideration of which was hitherto unnecessary. Plans of campaign must be improved upon and made very much more aggressive.

That Central Station Managers are rapidly appreciating this fact is evident from one feature of publicity work—that of the distribution of educational advertising matter—for over 120 Central Stations are now distributing such literature at more or less regular intervals, whereas a couple of years ago the station that did this was the exception.

That there is an urgent need for a thoroughly organised system of educational publicity in connection with the electricity supply business is very evident from a consideration of how little use the average electrical engineer makes of the various applications of electricity in his own home. Possibly the principle that the cobbler's children

are the worst shod may account for this fact, but it is certainly the exception rather than the rule to find the lighting arranged in accordance with modern ideas of illuminating engineering, or with the controlling switches, etc., placed in such positions as to ensure the maximum of convenience and economy; while as to cooking and heating apparatus many seem to think that these devices are still in the region of toys and playthings, and probably do not realise their function and place in the ordinary household. This indicates how very essential it is that the general public should be properly educated in matters dealing with the various applications of electricity in its homes and places of business; for until it is brought to fully appreciate the many advantages electricity offers by ameliorating the conditions of everyday life, by saving labour and time, and by adding convenience and comfort, it cannot be expected to become a consumer to any great extent.

In the majority of Central Stations the operating expenses are already brought to an almost irreducible minimum, so that very little addition to profits can be anticipated from any further economy in production under present conditions. Notwithstanding this present high degree of economical operation the financial state of the average undertaking cannot be said to be at all satisfactory. So it is self-evident that the only way to add to the profits is to create a demand for an increased output at an improved load factor, and to ensure that the existing distributing mains are fully occupied, especially in the immediate neighbourhood of the Central or Sub-Stations.

The necessity for the adoption of modern methods of increasing business is emphasised at the present moment by the rapidly increasing use of highly efficient metallic filament lamps, which everyone connected with the industry recognises will be to its ultimate advantage, but in the interval that must be passed over before these lamps are reduced in price sufficiently to become universally employed, and also before the rates for current can be adjusted accordingly, a very awkward situation is being brought about which can only be remedied by an increase of business.

Now an analysis of modern methods of increasing the sales of electrical energy at profitable prices, shows that these methods may be considered under three main divisions, which must, however, to a certain extent overlap.

(1) Good service.
(2) Canvassing.
(3) Advertising.

Good Service.

It is insufficient under present conditions for the term good service to merely comprehend a steady voltage and an uninterrupted supply, for more still will be required if the greatest possible success is to be achieved.

(a) Assistance to Consumers:—The Central Station management will have to lay itself out even further than it has done in the past to systematically act in an advisory manner to its consumers and prospective customers, advocating to the point of insistence if necessary, the best and most economical methods of using the energy purchased. As regards lighting in particular it is essential that the staffs of Central Stations should be very much better versed than they are at present in the principles of illuminating engineering, so that they may be in a position to guide users aright.

Another matter that will require more attention is that of supervision and assistance in the maintenance of consumers' installations and apparatus in a high state of efficiency. This is a thing that apparently trespasses on the province of the wiring contractor; however, it is the exception rather than the rule to find a town in which the contractors are sufficiently alive to their own interests in this respect, or are able to convince electricity users of the advantages that would accrue to them by having their arc lamps systematically trimmed, and their other apparatus regularly inspected. Now the Central Station Manager, in virtue of his recognised position of impartiality, can easily arrange to get this work carried out with a resulting increase of satisfaction with electricity on the part of the consumer, which naturally benefits the Central Station, for a satisfied consumer is one of the best canvassers the undertaking can have.

(b) Maintenance of Consumers' Lamps:—If the local circumstances are such as to make it advisable and feasible for the Central Station to undertake installation maintenance or lamp trimming contracts, this should be done; either at a separate fee or on the basis of a rate per B.O.T. unit, which includes the cost of the current and the cost of the trimming, etc. Otherwise it would be well to endeavour to place a contract annually for the whole of such work required in the area of supply, with one of the local wiring contractors.

(c) Method of Charging for Current:—A satisfactory and remunerative tariff is a very difficult matter to decide upon, and one that requires careful attention, since it is of great importance in keeping existing consumers satis-

fied and obtaining new ones. One feature to which insufficient thought seems to have been given by those who attempt the complicated problem is that of the part borne in it by the human element as exemplified in the consumer. The maximum demand system fails in this point, that the consumer who tries to comprehend it, in his endeavour to comply with its conditions, is continually turning out lights for fear the indicated demand will rise. This means a consumption of fewer units than would be the case if there were no restriction in the demand—a disadvantage to the Central Station. To overcome this defect it would be advantageous to use an auxiliary device which would announce either by bell signal or the dimming of the lights that a certain maximum had been exceeded, thus warning the consumer to turn out one or two lamps before the purposely sluggish demand indicator registered the new demand. A thermostatic or a solenoid device for this purpose could be obtained at a very reasonable price. Still, it is a moot question as to how much the Central Station load factor is improved by the use of maximum demand meters in private consumers' houses.

By far the best method is to have a different basis of charges for householders, shopkeepers, and power users respectively. The ideal basis for the householders would provide that—

(i) It is immaterial how many lamps are connected; this would encourage the use of electricity all over the house.

(ii) It must be easy to understand.

(iii) There must be no restriction that would check waste on the part of the consumer.

(iv) There should be only one circuit and meter for lighting, heating, cooking, and power.

Most Central Stations now possess a good deal of accumulated data concerning the maximum demands for current by house consumers, for which averages could be estimated for houses occupied, (*a*) by the upper middle class, (*b*) by the lower middle class, and (*c*) by the working class; the line of demarcation being defined as being between certain limits of the rateable values of the houses. On this basis up to the equivalent units that would be consumed by the first 90 hours use of the assumed maximum demand per quarter, the units taken would be charged at a high rate, and all beyond at a low rate, as is done at present in the Wright system, the low rate being such as to encourage the use of heating appliances and being based on the running costs of the station only,

the capital and standing charges being included in the high rate. From a theoretical point of view such a system is somewhat deficient, but regarding it in a practical light it will be appreciated that in operation it will mean satisfied consumers, the load peak will be considerably flattened out, and the total units sold will be increased. A few consumers will be slightly overcharged and some undercharged for light, but the mean, taking into account the facilities available, will work out to the mutual advantage of the Central Station and the average consumer. It would appear that the Central Station would have to take certain risks, but it must be remembered that this is more than counterbalanced by the increased revenue due to the sale of current for heating purposes.

The suggestion which has just been made is really a modification of the Norwich system.

Another method, which the writer believes is novel, would be to base the main charge (representing interest and standing charges on the plant) on the total area of the rooms, etc., to be illuminated, plus a rate per unit (based on the running costs) which would be sufficiently low to allow of the free use of heating and cooking appliances on the same circuit as the lamps.

In this way the proposition seems to be fairer than one depending upon the rated value of a house, which may vary according to the size of the garden surrounding it. It may be pointed out that there would be a difficulty in arriving at the areas of the rooms. In practice this might be overcome by actual measurement of the sitting rooms and kitchens only, making a standing allowance for bedrooms, passages, etc.

To apply this method of charging, a standard of illumination would have to be decided upon, say 3 square feet per candle-power (at a consumption of 4 watts per c.p.). The actual amount of the main charge would be arrived at by a study of the average demands of various classes of houses. This scheme has the advantage that it would bring in a certain fixed amount per house per annum, and it would also be of benefit to the Central Station when metallic filament lamps are made in smaller units and so begin to be used to a greater extent in private houses in place of carbon lamps

The idea of this system is to take as the basis of the charge that which the people are really buying, which they actually want, viz., illumination. The system also prevents an unreasonably extravagant advantage being taken of the terms offered, by still retaining the meter.

At the same time it is suggested that it fills in a large measure the ideal requirements that have been laid down.

Lump sum or contract rates have been proposed and tried, but experience shows that it is a bargain in which the Central Station comes off the worse in the long run.

For the window and sign lighting of shops it is best to adopt a charge based on the use of an hour meter with discounts for excess use of over a certain number of hours. If desired, the hour meter could also be made to apply to the interior lighting, or a somewhat similar system to that suggested for private houses could be adopted. An advantage of the hour meter, bevond the fact that it is so easily understood, is that it encourages after-hour window lighting for advertising purposes. Where practicable it is advisable to make the hour meter rate include the cost of trimming arc lamps, so as to lead to an increased use of the lamps.

In dealing with power users, it is better to have a tariff that, first and foremost, favours increased use and steady average demand, rather than to sacrifice anything to that simplicity of explanation which is so desirable in the case of householders and shopkeepers.

(d) Reduction of the Cost of Service Connections:—It is of importance that the capital invested in service connections should be as low as possible, though at the same time a service should not be a weak link in the distribution system. In a well-managed undertaking the cost should not exceed an average of £4 per consumer. The interest on expensive services means an additional item of cost to be added to the price of current.

Canvassing.

In these days when the technical side of Central Station operation is becoming more of a routine nature, it is essential that much more attention should be given by the manager to the prospects of developing business in the area in which electrical energy is supplied by his Undertaking, attending personally to the more important possibilities, and getting his assistants and canvassers to look after the smaller business on a systematic basis. The weak feature of canvassing, as a rule, is the fear that the calls may be overdone and do more harm than good by becoming a nuisance to the prospective consumer; with this danger in mind the calls are apt to become too infrequent. With the object of overcoming this trouble, a card-record should be kept of every call, and in this way, by frequent reference to the card-file, a check will be

afforded that will ensure that the interval between calls is not too long or too short.

Canvassers should be educated and trained in such a way that they may become representatives of the Undertaking in the fullest sense of the word. A properly accredited representative should be the personification of an officer of the company to the consumers and prospective consumers in his district. A possible user of electricity has not much respect for the business methods of an undertaking which sends someone to see him who makes use of such statements as "I do not know if we can do this or not, but I will see what the General Manager says." A canvasser must be thoroughly coached and posted in those matters with which he has to deal, for it creates a bad impression if the prospective consumers find out that they are talking to someone who does not know much more about things electrical than they do. Amongst the information the canvasser should have at his disposal are data as to the average bills of customers, the number of units consumed per 30-watt lamp installed per annum in various classes of business, the number of hours various sizes and types of lamps can be lighted before they consume a unit, the cost of operating various types of cooking and heating appliances, etc.*

A very important point which the canvasser should bear in mind in his work at the present time, is that he must take full advantage of the metallic filament lamp by seeing that existing consumers get more light for the same money, rather than allowing them to maintain the same standard in accordance with the catch phrase that appears so often on hoardings, "Your electricity bill halved."

No matter how many arguments for and against there may be, there can be no doubt but that in the majority of cases there will be a decrease in revenue from each consumer who changes to high efficiency lamps, unless the Undertaking is properly represented.

In many instances consumers now use carbon filament lamps, hung as low as possible. A demonstration of tungsten lamps may result in an installation of these, hung high and giving excellent illumination at only slightly increased cost for energy. There are many places where larger units of light, such as gas arc clusters, will be replaced by a larger number of smaller electric metallic

* A handbook prepared by the author especially for canvassers, containing data of the nature just referred to, is about to be published under the title of "Electricity for Everybody" (Electrical Press, Ltd., publishers).

filament lamps so as to take advantage of the better distribution of light then rendered available, and if the Electricity Supply Undertaking can assist in the planning of the installation, the consumer will get better results and the Undertaking an increased revenue. As regards existing consumers, the metallic filament lamp should be the means of raising the standard of illumination, and as concerning prospective consumers, the lower cost for light will be a means of persuading them to use electric light. Further steps must be taken to replace any revenue lost on account of the use of more efficient lamps, by the introduction of heating and cooking appliances. From an academic point of view electric heating is not in an ideal position as regards economy. But then the question arises as to whether strict economy can be regarded as the supreme aim of the general public. In matters of dress and food this certainly is not the case, therefore why take it for granted that electric heating will never be adopted except for the reason that it costs less than any other method. The inaccuracy of such a supposition has been demonstrated by the rapid increase in the use of electricity for lighting purposes even before it was obtainable at the present cheap rates. Convenience, comfort, and luxury appeal very strongly to most people, and if it is proved to them that electric heating can offer reliable, useful service, surpassing coal and gas in comfort and convenience, then in the majority of instances the prospect of a slight increase in cost will not deter them from taking advantage of electricity, especially when they realise that they can do many things electrically that are not feasible or practicable by any other means.

Advertising.

To ensure a successful interview for a canvasser the way should be prepared by interesting the people whom he is eventually to call upon in electrical matters. This can only be done by some form of educational advertising. Electrical advertising of itself rarely brings in and clinches business, but it awakens interest in the recipients and they are then more easily converted into consumers.

One great cardinal feature of advertising that seems to be consistently overlooked by Central Stations is the need for persistency and regularity in the distribution of advertising matter. Often also, electrical advertising literature is not as well printed and attractively got up as it should be in order to stand out amongst the mass of advertisements with which every householder is nowadays so plentifully supplied.

Originality in design and the copious use of illustrations all tend to attract more careful attention on the part of casual readers, and to leave a more vivid impression on their minds, hence these aids should be freely used by Electrical Undertakings in their advertising campaigns.

A localised electrical bulletin or magazine issued say at monthly intervals is of great value in educating both prospective customers and present consumers as to the possibilities of the applications of electricity in their own homes and places of business, it is also of great assistance in overcoming the ignorance of the general public concerning electrical matters generally, for there are still many people who associate an electricity supply service with thunder and lightning. Separate magazines should be employed for power and lighting respectively, as those interested in the former are but a small section of the community. Even then there is the danger that the articles may be so general in character that they will fail in attracting the attention of the reader. For that reason and to induce him to read them, strictly local and personal notes should be added dealing with electrical matters and happenings that occur within the area of supply. This idea is being carried out in a number of towns with success, and it is found that the local shopkeepers especially appreciate any notice of their business and enterprise.

As regards the distribution of the advertising matter, since postage is too costly except for special cases, an improved plan on the present method of sending it out by hand, loose and unprotected, would be to distribute it in sealed, addressed envelopes, thus attracting much more attention than the present method, and ensuring that it reaches the hands of the master of the house, or principal of the business.

Conclusion.

Salesmanship is an art which does not as yet seem to have been properly applied to any extent in connection with the distribution of Electrical Energy in this country, though in the warehouses of London and Manchester sales departments are organised to a superlative degree—higher, perhaps, than in any other country in the world. It is, therefore, all the more surprising that the electrical business should have been so neglected. However, there are signs of a great change, for during the past two years especially, great strides have been made, this advance being partly due to necessity and partly to enterprise and example. Station after station has proved to its own satisfaction that up-to-date commercial methods do pay in that retail business known as electricity supply.

APPENDIX.

A question that often arises is as to what amount should be expended by a Central Station on publicity matter, and the following schedule, which is an actual instance, will doubtless be of interest. It should be noted that all this literature is localised, as suggested in the section of this paper under the heading of "Advertising":—

Jan.	21.—	40 copies.	*Power Magazine.*
Feb.	1.—	3,000 ,,	*Electrical Bulletin.*
,,	22.—	40 ,,	*Power Magazine.*
March	1.—	3,000 ,,	*Electrical Bulletin.*
,,	15.—	3,000 ,,	*Circular Card Advertisement.*
,,	22.—	40 ,,	*Power Magazine.*
April	1.—	3,000 ,,	*Electrical Bulletin.*
,,	1.—	3,000 ,,	*Pictorial Reply Post Cards.*
,,	21.—	40 ,,	*Power Magazine.*
May	1.—	3,000 ,,	*Electrical Bulletin.*
,,	1.—	3,000 ,,	*Pictorial Post Cards.*
,,	21.—	40 ,,	*Power Magazine.*
June	1.—	3,000 ,,	*Electrical Bulletin.*
,,	21.—	40 ,,	*Power Magazine.*
July	1.—	3,000 ,,	*Electrical Bulletin.*
,,	21.—	40 ,,	*Power Magazine.*
Aug.	1.—	3,000 ,,	*Pictorial Cards.*
,,	21.—	40 ,,	*Power Magazine.*
Sept.	1.—	3,000 ,,	*Electrical Bulletin.*
,,	15.—	3,000 ,,	*Leaflets.*
,,	21.—	40 ,,	*Power Magazine.*
Oct.	1.—	3,000 ,,	*Electrical Bulletin.*
,,	1.—	3,000 ,,	*Enquiry Cards.*
,,	21.—	40 ,,	*Power Magazine.*
Nov.	1.—	3,000 ,,	*Electrical Bulletin.*
,,	22.—	40 ,,	*Power Magazine.*
Dec.	1.—	3,000 ,,	*Electrical Bulletin.*
,,	21.—	40 ,,	*Power Magazine.*

Also the following pamphlets for the special use of canvassers:—

200 copies dealing with the applications of small electric motors.

200 copies dealing with the installation of electric light.

800 copies, in which the merits of electric light are discussed.

800 copies giving information about cooking and heating.

A total of 50,480 appeals. The cost of editing, printing and publishing was £80, or 0.38d. per appeal. This represents an average of 15 appeals per annum to each prospective consumer, or a cost each of 5.7d. for a period of twelve months.

The above literature is for four Undertakings operating in areas having a population of about 11,000 each, so that the cost to each is about £20 per annum—a very reasonable figure, especially when it is borne in mind that the matter is localised for each Undertaking. It would be well to add to the above the cost of two imitation typewritten circular letters. The sum named does not, of course, include postage and delivery.

The schedule given above was selected as being suitable for certain particular areas, and would not necessarily serve other districts as satisfactorily.

STORMS, AND THEIR EFFECT ON THE SEA COAST.

By J. S. Owens, B.A., A.M.Inst.C.E., F.R.G.S., M.D.

[Read on Friday, April 2nd, 1909.]

In this paper the subject of storms and their action on the coast line has been dealt with on somewhat general lines. Although the nature of storms has been gone into at rather greater length than might at first sight appear necessary, the author thinks that, to consider their action intelligently, attention should also be given to the nature and causes of these disturbances. He hopes therefore that he will be pardoned for going over what, to most of those present, must be old ground.

Although it may be of interest to study the effect of a storm while it is raging, or after it has passed by, very often much can be gained by knowing just what to anticipate. For example, in nearly all marine or coast works we might often avoid serious damage to the work during construction if we had reason to believe that a bad storm was approaching. Loose timber could be made fast, or removed beyond the reach of the waves; concrete would not be deposited in exposed positions; and, generally, things could be made ship-shape to withstand the coming storm with the least amount of damage. Many instances where damage might have been prevented will no doubt occur to those present, and it is unnecessary to labour the point; suffice it to say that it is of great importance to engineers, especially such as deal with sea works, to know, not only what the probable effect of a storm will be, but also whether or not one is likely to come.

With these few words by way of introduction, we pass on to a consideration of storms and their nature.

All weather disturbances may be said to originate from the sun's heat; without this our atmosphere would become like a stagnant pond, free from all currents. There is little doubt also that such a state of stagnation would result in evils to mankind, the very nature of which we can only surmise. Foul and heavy gases would lie about in the hollow valleys of the earth, which would therefore probably become uninhabitable. The waters of the sea would never have a ripple on their surface, and the only movement would be the heavy to and fro swing of the tides; little oxygen would be absorbed by the oily surface

of the waters, and fish life would probably be impossible. We must look at winds and storms as being beneficent in their nature on the whole, and only injurious when regarded from our own very limited point of view. Although we may broadly explain all weather disturbance as simply the working of nature's machinery for restoring equilibrium, which has been disturbed locally by the sun's heat, the explanation does not go very far. It is as if one said with reference to a great Atlantic liner that the explanation of its motion was this: a supply of fuel was fed into a certain orifice or orifices inside the liner, and this resulted, without going into the details of the process, in causing the liner to travel through the water. All the thousands of interests relative to the designers, owners, passengers and crew are not touched by our explanation. This is perhaps a digression, but the author cannot resist drawing attention to the hundreds of explanations we are satisfied with in dealing with natural forces, which strictly speaking explain nothing. It is strange how satisfying long words are which simply give a name to prime forces, concerning the nature of which we know nothing, for example: "electricity," "gravity," "magnetism," "chemical affinity." However, to return to our storms:—Those which we experience are really secondary disturbances in a gigantic system of atmospheric circulation. There is a constant heating of the air in equatorial regions which results in an increase of its volume. If we consider the earth to be surrounded by an envelope of air of uniform thickness, it will be seen that any local increase of volume must result in a sort of bulging upwards of the outside of this envelope over the heated area, and as a result of this, an outflowing current will be established from the heated part, over the surface of the atmospheric ocean. Thus over the equatorial region we get a tendency towards a steady upper current pole-wards, and a consequent inflow underneath, towards the equator; to relieve the pressure due to the piling up of the air in the colder regions which has been brought up by the above mentioned upper equatorial current.

Ferrel showed that the rotation of the earth on its axis caused an eastward deviation of all currents flowing towards the poles from the equator, and a westward deviation of all flowing from the poles towards the equator. Hence we have the N.E. trade winds of the northern and the S.E. of the southern hemisphere.

We see therefore that to establish atmospheric currents *uneven* heating of the air is necessary. During the summer months, when certain parts of the country become

more heated than others, the superincumbent air becomes heated also, and on expanding an upward current is established. On attaining a certain height the reduction of temperature resulting from expansion, due to relief of pressure, causes the water contained as vapour to condense into mist or cloud, and we get the ordinary local summer shower. It would seem as if one caught a glimpse here of nature's automatic adjustment to requirements, for it is certainly the dryest and most parched parts of the country which thus tend to become over-heated, and so possibly produce rain to relieve their own drought.

Such local disturbances cover only a small area. The great storms which affect the whole British Isles at once, have their origin, perhaps, thousands of miles away, and travel to these islands along certain recognised pathways. Seldom indeed do we get widespread storms which do not come to us over one or other of these paths. There are two storm centres which are responsible for sending us nearly all our weather disturbances: one situated in Mid-Atlantic and one to the S.W. of Iceland. From mid-Atlantic they travel eastward to our islands, often appearing to halt for a time about the Irish Channel; thence they may travel S.E. or E. through North Germany, towards the N. through Ireland, or N.E. towards Christiana.

The storms coming from the centre to the S.W. of Iceland usually travel in a S.E. direction through the North Sea.

There seems to be a tendency for storms to have their progressive movement retarded when they come over large masses of land; but this retardation does not affect the violence of the storm itself.

Turning now to the nature of such great storms, we find that they are always of a rotary character, and are known as cyclones. They are gigantic whirlwinds, often over a thousand miles in diameter, which, while having a motion of revolution round a centre, have also the progressive motion of the whole disturbance above referred to. There appears to be no relation, however, between the progressive and rotary motions. The average rate of the former for storms from the Atlantic appears to be about 20 miles per hour, but the motion is not uniform, as pointed out above, and may sometimes cease altogether for a time, the storm remaining stationary.

In the northern hemisphere the rotation is anti-clockwise, and in the southern clock-wise; the air pressure diminishes as the centre approaches and rises as it recedes. Lines of equal pressure or isobars may be drawn for any storm and they are roughly concentric circles surrounding

the centre of the storm. Near the latter, and somewhat in front of it, is the rain and cloud area, where the pressure is least; surrounding this is a ring of cloud, and beyond the cloud is a clear sky. The low pressure at the centre precipitates the water from the air, hence we get rain here. To find the position of the centre of a cyclone we may apply Buys Bollot's Law:—If we stand with back to the wind the centre will be on our left hand in the N., and on our right in the S. hemisphere.

The rotary motion of such storms is due to the earth's rotation on its axis; as mentioned before, this causes an eastward and westward deflection of currents flowing poleward and equator-ward respectively, and this results in a whirl or motion when air rushes from all directions towards a low pressure centre. Redfield and Espy describe whirlwinds generated thus by great forest fires; but it is clear that to permit the earth's rotation thus to initiate a whirl, a very large area of the surface must be affected.

The movement of the air in a cyclone is not a simple revolution round a centre, but is of a vorticose nature, the air working towards the low pressure centre in a spiral.

As a storm moves from its point of origin its diameter gradually increases; the extent of the initial disturbance depends upon the area of the initial upward current; when this is established the gyratory movement extends outwards, and the velocity of the whirl increases until the frictional resistance due to increase of size and velocity becomes equal to the generating force; the limit of violence and initial dimensions is then reached. After this the storm, moving away from its origin, grows in dimensions and diminishes in violence with its age. In the Indian Ocean the diameter of cyclones is said to be from 50 to 250 miles. Redfield states that those in the lower latitudes of the Western Atlantic are about the same diameter. The typhoons of the China Sea appear to vary from 60 miles to 3 or 4 degrees in diameter. In higher latitudes the diameter is usually from 1,000 to 1,500 miles, the low-pressure centre being perhaps 200 to 250 miles across.

The weather disturbances known as anti-cyclones do not call for much attention here, as they are rarely violent and do not properly come under the heading of storms. They are also rotary disturbances revolving in a direction opposite to that of the cyclone, having high pressure centres and a centrifugal air flow. It is believed that all well developed cyclones have, superimposed upon them, anti-cyclones due to the outflow of the air in high altitudes which is passed up the low-pressure cyclonic centre.

Reference has been made to the isobars of a cyclone,

or lines of equal pressure, which are of the utmost importance in predicting the weather. The direction of the wind is nearly parallel to the isobars, and the closer the latter are together on a weather chart, the more violent the wind which may be expected. The violence of the wind depends upon the steepness of the barometric gradient, and not upon the height of the barometer at any one place. Thus close isobars mean a steep gradient, and this in turn means violent winds.

When considering the effect of such storms upon the coast we have to remember that the water tends to flow towards the areas of low pressure, and thus to raise the surface level over the area covered by the centre of a cyclone, and each inch of height in the barometer will produce about a foot of alteration in level of the surface of the sea. The importance of this is sometimes great, as we may get the extra foot of height on the top of a high spring tide with a rough sea, and it may just suffice to top our embankments and perhaps flood valuable land.

The violence of the actual wind is not of primary importance, as however high it may be several conditions entirely independent of it must be fulfilled before the storm can have much effect upon the coast. These will be dealt with further on. It may be said here that although storms produce great havoc on the coast under certain circumstances, it is not always the violent storms which produce the greatest results in moving shore materials. The steady wind which blows from the same quarter for a long time has an even more powerful effect, especially is this so on coast lines facing from south to east in this country, since they are thus exposed to the full effect of the two most prevalent winds, the S.W. and N.E.

The prevalent winds are simply the expression of the movements resulting from the barometric gradients as indicated by the isobars for any particular time and place. The N.E. and S.E. trade winds are marked examples.

In England the prevalent wind is from the S.W.; it blows from this quarter twice as often as from any other, the yearly average for 20 years at Greenwich being 103 days for S.W. winds. It is curious to note that an examination of wind records for the northern hemisphere shows in nearly all cases two maximum directions, those for England being S.W. and N.E. in the ratio of about 2 to 1.

The velocity of the wind in storms sometimes reaches the extreme value, according to Ferrel, of 310 miles per hour; which he says would produce a pressure of about 300 lbs. per square foot against a normal surface. According to Dr. Stanton the pressure due to this velocity would

be 259 lbs. per square foot. Such velocities only occur in violent tornadoes, which are capable of blowing trees and baulks of timber about like feathers. In an account of the tornado of August 9th, 1878, at Wallingford, Conn., it is stated that pieces of timber were driven with such force against some apple trees as to embed themselves 6 or 7 inches in the trunks. We do not get winds of such force in England.

Dr. Stanton's formula for wind pressure on a normal surface is as follows :—

When P = press. in lb. per square foot,
V = vel. of wind in miles per hour, then
$$P = 0.0027V^2.$$

The pressure depends upon the density of the air, and consequently on the humidity and altitude; it will of course be very much lower on the top of a high mountain than at sea level for a given velocity of wind.

Referring to the seasonal incidence of storms:—It is popularly believed that our severest storms occur at or near the equinoxes, hence we hear of equinoctial storms. The following table of results given by the Meteorological Council in 1889, showing the number of gales occurring in each month of the year, over a period of 15 years, does not bear out this theory. It will be seen that the most stormy months are November, December and January.

Table of monthly incidence of storms for the United Kingdom :—

Jan.	171.	May	12.	Sept.	55.	Direction N.E.	96.
Feb.	115.	June	10.	Oct.	133.	,, S.E.	165.
March	117.	July	11.	Nov.	158.	,, N.W.	279.
April	40.	Aug.	32.	Dec.	134.	,, S.W.	448.

Keeping in view the various storm tracks mentioned, leading to the British Isles, we see that a study of the weather charts, if available, will show the nature of the weather to be expected. The curved isobars will show where the centre of the disturbance lies, should there be any; and as the centre approaches rain and high winds may be expected. This method of foretelling the weather depends upon prompt telegraphic information being sent to the Meteorological Office from all stations in touch with it, as it is only by plotting the pressures from all stations on a map that isobars can be drawn.

The approach of a storm may then be known beforehand, and for the benefit of all whose work brings them into close touch with the sea, whether as sailors or civil engineers, a system of storm warnings has been adopted at most of our seaside towns and villages. Certain signals are hoisted on a flagstaff and kept up for 48 hours after

the warning has been received from the Meteorological Office. These signals are as follows :—A black cone point downwards indicates a gale from the S. ; a similar cone point upwards indicates a gale from the N. If an unusually heavy gale is expected a black drum is hoisted above the cone. At night these signals are replaced by lights arranged in a triangle.

They can be seen from a considerable distance and are very useful indications of the kind of weather to be expected. The author has often, when engaged on coast works, made preparations for a storm on seeing the warning cone run up.

From the circular motion of the air in cyclonic storms it follows that as the storm approaches, if the centre is to the north of the observer, as it nearly always is in England, the wind will tend to shift round from perhaps N.W. through W. to S., which is known as a "backing" wind; hence this nearly always heralds the approach of bad weather, especially if the wind shifts from N.W. towards S.E.

The temperature of the air is also a valuable indication of the nature of the coming weather, as it has a tendency to rise in front of low-pressure areas. Since difference of temperature is the most powerful cause of atmospheric disturbances, if it is found from the reports of other meteorological stations that great differences exist in the temperature of adjacent stations, then a serious storm is probable.

Unusual clearness of the air, so that objects can be seen clearly at great distances, indicates a coming gale.

The introduction of wireless telegraphy will give us considerable help in weather forecasting, as it is now possible to establish outlying stations in the Atlantic in the track of storms, and to maintain communication with them without difficulty.

Returning to the wind again :—It has been found that when east winds appear on the northern side of west winds, south winds, and possibly a storm, will almost certainly follow. When east winds occur on the south side of west it usually means that fine weather is coming.

The barometer, of course, affords an early intimation of the approach of a low-pressure area, with its usual accompaniment of bad weather. A rapid and unexpected rise is often the forerunner of a coming fall and storm, and such should always be viewed with suspicion. It is the unexpected storm which is most to be dreaded by engineers engaged in constructing coast works, not being forewarned they are unable to be forearmed.

Again, when we remember the effect of the barometric gradient, and the fact that most of our storms approach us from the West, we see that valuable information may be gained by watching the reports showing the height of the barometer in the South of France. If it is rising there and at the same time falling in England it aggravates the danger of storms owing to increase of the pressure gradient. In such an event a westerly storm may be expected. On the other hand a synchronous fall of pressure in England and the South of France indicates winds of less violence.

Owing to the indraught of air towards the centre of a cyclone, it frequently happens that S.E. winds on the west coast of France indicate the approach of a cyclone to our islands from the West.

Turning now to cloud indications :—

When we see the form of cloud known as "mares' tails" it is nearly always a certain indication of wind. A gale on the coast is often heralded by a bank of hard cumulus cloud lying to seaward over a dark haze. Small stratus clouds with hard outlines indicate fair weather, but if large and soft they may mean rain.

Halos, or rainbows, round the moon, are almost certain indications of a coming storm, as is also a yellow sunset sky, a red morning sky, or a "high dawn."

The indications of fine weather are :—Red sunset sky; grey morning sky; low dawn, or when the sun appears first on the horizon.

Ocean waves produced by storm winds may continue to roll on beyond the limits of the storm. When therefore rollers come in upon a shore without apparent cause they sometimes indicate a coming gale; but this is by no means always the case, as the storm may pass by some distance from us, but near enough to cause such waves to reach our coast. This is not an uncommon occurrence. Mr. A. R. Hunt* cites a case where a gale blowing on the south coast of Ireland on Sunday evening caused much disturbance at Torquay Harbour on the following Monday, although the storm never reached there.

Turning now more particularly to the effect of storms upon the coast : we find that in order to produce severe damage certain conditions must be fulfilled. High waves are not injurious to a structure unless they reach it ; hence we see that there must be sufficient water to enable the waves to travel. This means that for the majority of walls erected for sea defence the danger from wave stroke is

* "Denudation and Deposition by the Agency of Sea Waves," by A. R. Hunt.

limited to certain times of the tide, usually a little before and after high water. The direction of the wind must be such as to produce high waves, or in other words there must be a good fetch. The effect of the wind, in piling up the water before it, is also sometimes very great, and when it blows from such a quarter that it can do this effectively, such as from the N.E. down the North Sea, very high tides may result. As an example of the power of a high wind the following may be mentioned. The cyclone of October 31st, 1876, at Bakarganj, produced such a wave that the land to the east of the delta of the Ganges was flooded to a depth of 10 to 45 feet and over 100,000 people perished.

It has been stated by Lord Dunraven that breaking waves on the west coast of Ireland have been known to reach a height of 150 feet.

The highest recorded unbroken ocean wave is about 45 feet from trough to crest, and such would, when breaking, fling its spray to an enormous height.

Photographs of great waves are usually very difficult to obtain, as the conditions favourable to great waves are not those which are favourable to photography.

The author is fortunate in being able to show some slides of such waves, which reach the enormous height of over 140 feet. There happens to be in the photographs, which were taken at Aberdeen breakwater, a lighthouse which is 140 feet from water level to the top, and the waves stood well about this. Of course they are breaking or broken waves, and the height is due to the impact against the breakwater.

Leaving out the wave-forming effect of the wind, let us look at its current-forming power. This is a subject which has not yet been thoroughly investigated. The author believes that Capt. Amundsen, who is about to start on a new drifting voyage with the ice in the Arctic Ocean, intends to devote special attention to the effect of the wind in this respect. It is probable that near the coast, in shallow water, the wind is most effective in drifting fine bottom materials, but it would seem that the wind blowing obliquely on shore is more effective in causing drift than any other, and is consequently the most to be dreaded as a factor in causing coast erosion.

Storms affect the coast chiefly through the agency of sea waves and currents, although the direct action of a stormy wind is by no means to be neglected.

The movement of sand from foreshores which expose a large surface at low water is sometimes very considerable: this is shown by the formation of the immense sand dunes

which fringe our shores at some places. These dunes often tend to advance on the land by the transference of sand from their seaward to their landward face, and large areas of land have been thus devastated and houses and churches buried. Whole estates have been thus lost at Moray Firth, and on the Aberdeenshire coast. Villages have been buried in the South of Ireland, and in fact this inland march of the sand dunes, driven before the stormy wind, is a thing much to be dreaded. When such dunes are planted with marram grass or bent it affords protection from the wind and fixes the dunes. Maritime pines have also been found most useful for the same purpose.

It is surprising to notice the power of the wind to move even large stones in exposed positions. Sir A. Geikie records instances of pieces of flagstone weighing several pounds being detached from the cliffs during gales in the Orkneys and Shetlands, and carried upwards and scattered over the moor above.

The author can recollect a case where men engaged in trimming a chalk cliff to an even batter were working during a heavy wind which blew straight against the face of the cliff, the latter was about 80 feet high, and the chalk dislodged by the crow-bars of the men, unless when in large masses, failed to reach the foreshore beneath, being carried back by the wind and spread over the top of the cliff.

The storm waves and the currents generated in shallow water by high winds are, however, the great agents of coastal denudation and deposition. When a gale blows directly on shore it drifts the surface water against the shore and causes an undertow seaward, which is a powerful factor in carrying off suspended matter, and denuding the coast of sand.

Off-shore gales have the opposite effect and pile up the foreshore material against the land.

When the wind blows along shore it often causes a considerable current. Mr. G. O. Case's observations made on the Sussex coast in October, 1907, showed this. It is not easy to tell by observation what the effect of the wind in forming such currents is, and the data to be obtained are very scant. Mr. Case took observations of pieces of floating seaweed which were practically submerged and so not exposed to the direct action of the wind. During a gale from the S.E. he found that a current of from 0.65 to 1.50 feet per sec. was setting with the wind and contrary to the direction in which the tidal current at the time should have been flowing.

One cannot neglect the effect of such a current if ex-

tending to the bottom, for even the very slightest movement of the water during a time when it is full of suspended matter churned up by the waves is effective in transporting the material along the coast.

Leaving currents for the present and turning again to the effect of storm waves and their genesis. Still water, as is well known, reflects light like a mirror; this smooth reflecting surface remains intact although a breeze of about $\frac{1}{2}$ a mile per hour may blow over it, when the velocity increases to one mile per hour the surface of the water becomes covered by minute corrugations of the surface film; these are capillary waves which cease abruptly with the cessation of the breeze. If now the wind increases to about two miles per hour very small regular waves begin to form, of what Mr. Scott Russell called the "second order," the capillary waves disappear from the crests of the larger waves but are still to be found in the shelter of the troughs. These waves begin with an amplitude of about an inch and a length of a couple of inches, and in them we find the infant ocean roller, which under the influence of prolonged winds of high velocity may attain to grand dimensions of between 40 and 50 feet high and perhaps a quarter of a mile long.

During a heavy storm on the coast it is sometimes noticed that the highest waves do not occur when the wind is strongest, but a little after the wind begins to subside. This has been attributed to the wind, when at its fiercest, blowing off the tops of the waves, and causing a less regular system, whereas, when it has begun to abate, the irregular waves tend to unite into regular systems and so gain in size and power.

Mr. Thos. Stevenson's formula for the maximum height of wave due to a given fetch is empirical and as follows:—

$h = c\sqrt{f}$, in which h is the height in feet, f the fetch in nautical miles, and c a coefficient depending on the strength of the wind, which is taken as 1.5 for strong gales, thus the formula becomes $h = 1.5\sqrt{f}$. The height of the wave is therefore proportional to the square root of the fetch, or the distance from the windward shore. The formula is limited in its application by the fact that we cannot assume the wind as blowing in a straight line over the whole fetch. About 45 feet is the greatest height recorded for ocean waves, and this corresponds to a fetch of 900 miles. The formula is therefore obviously further limited in its application to great oceans. The influence of storm waves and winds in causing movements of the materials composing the foreshore depends greatly upon

what these materials are. In some places we can see the bare rocky skeleton of the land, picked clean by the hungry waves, projecting into the sea. There is not much damage to be apprehended here, as all the soft erodible stuff has gone; but when there is plenty of the latter we can observe the strange way in which it oscillates to and fro along the shore in obedience to the direction of the wind. It is not uncommon to find, after a sudden change of wind, that six or eight feet of sand and shingle have been shifted away from some parts of the shore in a single night, to come back again more gradually under the influence of favourable winds.

The author's object in this paper was to bring together some of the more interesting points relating to storms and their effect upon our coast, and to show also that a study of storms is by no means a waste of time on the part of the engineer, especially such as are concerned in the erection or care of coast works.

THE PAST, PRESENT AND FUTURE OF THE ORGANISATION OF THE ENGINEERING PROFESSION.

By R. O. Wynne-Roberts, M.Inst.C.E

[Read on Thursday, May 6th, 1909.]

When the Author was invited and had consented to read a paper this evening before the Civil and Mechanical Engineers' Society, the question arose as to what should be the subject, and it became one of complexity and difficulty, for it was almost impossible to suggest one that had not already been adequately dealt with.

However, when the Author was informed that the meeting was an eventful one—to celebrate the Jubilee of the Society—and that it was possibly the last meeting before amalgamation with the Society of Engineers, he thought that a few notes on "The Past, Present and Future of the Organisation of the Engineering Profession" would be appropriate to the occasion.

The life of your Society has been an honourable one, extending as it has done over fifty of the most eventful and important years of the development of British engineering. The activity of your Society has been collateral with the unprecedented progress of this country, the empire and the world generally, and it has occupied no mean part in the work of giving corporate life to our profession.

When we reflect upon the fact that Great Britain was once an insignificant, despised, fog-bound island, where foreign engineers started our mines, built our ships, windmills, water-mills and pumps, cast our cannons, carried out our drainage works, constructed our harbours and developed our industries—for we then had no native engineers, and, indeed, even later on such work was considered ungenteel by our educated classes, as even Smeaton was criticised by some of his friends of the Royal Society for having undertaken the "navvy" work of making roads—we are inclined to rub our eyes in astonishment.

Then arose our early predecessors, who were men of

grit but of little education, geniuses although not scholars, endowed with indomitable will, and but little polish—men who wore brown coats and bob-wigs, characteristic of those below the rank of gentlemen, but who, nevertheless, laid the foundation of our profession which has since grown in magnitude and importance far beyond the most sanguine anticipations.

It was soon felt by the early engineers that some organisation was necessary to enable meetings to be held for discourse and mutual good-fellowship, and it was under these conditions that in 1760 the first Society of Civil Engineers was formed, which the Author believes still exists under the name of the Smeatonian Society of Civil Engineers.

In 1817, seven enterprising young men, anxious to have opportunities for meeting to discuss matters of interest and for mutual self-help, decided to start a new organisation, which in another ten years received its charter, and was called the Institution of Civil Engineers.

Other societies were started in course of time, each with its own particular field of operations, interests and objects, and thus we find that the Institution of Mechanical Engineers was started in 1847, the Society of Engineers in 1854, the Civil and Mechanical Engineers' Society in 1859, the British Association of Gas Managers in 1863, and, in 1871, the Institution of Electrical Engineers.

It is not proposed to trace the history of our various societies, for that has already been done by gentlemen possessing the fullest information, and, moreover, that is not the object of this paper.

Yet such in outline is the history of the movement of establishing societies in this country in connection with the profession, and we might here digress from the main subject for the purpose of reviewing the events of the decade in which your Society and others were formed, for this period is prolific in historical facts. Roads were being constructed in other countries, some under grave difficulties and with great engineering skill, enabling vehicles to be hauled across sand flats in less than one-tenth the time, and with infinitely less hardship to men and beasts.

The Menai and Conway Tubular Bridges were completed in 1850. In 1851 the first great Exhibition was held in Hyde Park in what is now the Crystal Palace; the first submarine cable was laid between England and France; the first mail steamer made her voyage to the Cape in about forty days; the first alluvial goldfields

were discovered in Australia; quicksilver was found in Mexico. In that year also Weber developed a definite system of electrical measurement expressed in absolute units. In 1853 the first great India railway scheme was authorised; the first constitution granting self-government to Cape Colony was promulgated. Next year Great Britain was embroiled in the disastrous Crimean War, when field sanitation and efficient hospital and commissariat organisation received their first and legitimate attention. In 1855 David Livingstone discovered the famous Victoria Falls with their enormous descent of 400ft., and gave the public the news of his discovery. It then occupied many months to travel from Capetown to the Falls, but to-day the journey can be made in comfort in as many days. Next year Siemens invented the regenerative gas furnace for the manufacture of steel, and Bessemer introduced his improved methods of steel production, the effect of which has been to revolutionise the whole system of metal construction. The Indian Mutiny occurred in 1857. The first submarine cable across the Atlantic Ocean was laid in 1858, dissipating the obstacles of space and time, and bringing the outside world into more intimate relationship with ourselves. The first railways were built in Australia; Canadian railways were in course of construction; the famous Victoria tubular bridge was completed in 1859; the Suez Canal was commenced in 1859, and completed in 1865; and the railways in Russia and other countries were in their infancy.

During this period we had no properous colonies. We certainly had possessions, but they were thought burdensome, and involved great responsibilities. Some were not even known or explored. In 1854 Louis Napoleon declared himself Emperor of the French. India was under the East India Company until 1858, when the government was transferred to the Crown, and the Queen formally proclaimed its Sovereign. Canada was not federated until 1867.

Neither Johannesburg and the gold mines, nor Kimberley and the diamond mines were yet in existence. Japan was groaning under an ancient feudal despotism of the severest type. Egypt was also under the rule of despots, and the Soudan was beyond ken for all practical purposes. Germany was composed of a number of heterogeneous kingdoms, and waiting for some force to weld the whole together. Italy was in the process of emancipation from Papal control.

Great Britain, despite her external troubles, was expanding her industrial and commercial operations. New vision was being given to engineers, vigorous life was being instilled into, and abundant energy generated by our profession.

As Mr. Charles Hawksley, M.Inst.C.E., very ably stated in his presidential address in 1901: "At the commencement of the last century engineering works were comparatively few in number, and consisted principally of roads, tram roads, canals, bridges, harbours, docks, lighthouses, waterworks, drainage works, mines, and pumping and other stationary steam engines."

During the last fifty years, however, electric telegraphs and telephones, light, traction and power, and electricity in all its phases have been brought into daily practical use. Gas, oil, petrol and other internal combustion engines have been invented, and now occupy an important position in our industrial and engineering world. The warships to-day are floating machine shops depending on the efficiency and the nerves of engineers, and fortifications are equipped with various forms of power. Warfare is now largely a fight for supremacy between engineers of different countries. Chemical works, bacteriology, sanitation, refrigeration, large steel ships—in one of which more power is generated in a single voyage across the ocean than was necessary to build an Egyptian pyramid—hydraulic machinery, utilisation of gases and waste products, development of gas manufacture, extension and improvement of railways, aerial navigation, and other items too numerous to mention, have now assumed great importance in the engineering world, giving employment to a great number of engineers and workmen, and contributing to the powerful influences which have changed our industrial, commercial and social life, our requirements, our education, and our ideals; one proof of which is that, in 1857, the number of passengers conveyed on our railways was about 139 millions, whereas to-day about 1,500 million passengers are carried in each year, showing that the desire and necessity for travel expands with the changes which take place.

Fifty years ago there were not 1,000 members of all grades of the Institution of Civil Engineers; to-day there are nearly 9,000, and even this figure does not by any means represent the number of British engineers employed in various parts of the world. There are many members of other societies who are not included in the roll of the Institution of Civil Engineers, and there are also many of

the profession who are not associated with any society at all. It is therefore obvious that the total number of British engineers engaged in all branches of the profession cannot be estimated with any degree of accuracy, yet, for the purpose of comparison, it may be safely asserted that it approximates 20,000.

There are at the present moment a number of important questions exercising the minds of engineers, and among them is that of registration. To many members of our profession this is a consummation to be devoutly desired. Some are sanguine enough to predict that great improvement in our status, emoluments and etiquette would result therefrom. Under such conditions as prevail in this country, the colonies and in foreign countries, assuming that it is feasible within a reasonable period to effect such a change, will a closed profession be beneficial to the members? Will the status be elevated by registration? Does the nature of our calling, precarious as it must be, owing to employment terminating with completion of work, and its migratory and uncertain character, permit of registration?

The question of emoluments would doubtless receive careful attention if registration became a "fait accompli," and some scale would be established to regulate the same, such as applies to doctors, architects, surveyors, etc. But, despite such official tariffs or scales of fees, doctors are often obliged perforce to accept reduced payments from various public bodies for their services. Architects and surveyors do not always adhere to their recognised scales, and injustice is thereby inflicted on others.

During the past fifty years the educational system has been developed to such an extent that the poorest lad can by ability gain an entry into the best available engineering schools and colleges in the land—and rightly so. The number of students at our universities, colleges, institutes, schools, etc., has grown enormously, and often without much or perhaps any office or workshop experience many are straightway placed in positions of responsibility, involving the control of workmen and large expenditure of money.

Indentureship or apprenticeship is gradually disappearing. Training is now considered by some to be more academic and theoretic, and less practical than of old.

The records of the Institution of Civil Engineers show that, in 1870, there were then but 173 students on the rolls, whereas to-day they number about 1,500. This rate of increase will doubtless continue in the future, for,

as new inducements and excellent facilities are being afforded, additional contingents of young aspirants will be poured forth.

Although almost every profession and craft appears to be overcrowded, yet it is a reasonable question to ask, what will become of our young engineers and students? Will they all be able to find employment in their professional capacity, or will many of them be compelled to turn their attention in other directions, and abandon the expensive training which they have received?

Under the laws governing demand and supply, it is not always the survival of the fittest, for there are many brilliant men who have not succeeded, owing to circumstances over which they had no control.

During the last half century the British engineer was employed in almost every known part of the world, constructing railways and bridges, harbours and many other important works, which have reflected infinite credit on the profession, and on this country generally, creating a prestige which has still a powerful influence for good.

Those were the palmy days, when, in the absence of foreign competition, Great Britain had the reputation, the means and the men such as no other nation possessed, and work literally poured into her lap without much strenuous exertion.

At home there was also ample scope for the engineer. Public works of all kinds were carried out. Municipalities were energetic in the execution of sanitary work and public improvements, railways and tramways, industrial, engineering and other schemes were in course of rapid development, all of which called for engineers. Here again competition was practically a negligible quantity. Stately dignity prevailed among the leading men. Their names were household words, and there was therefore little need to introduce them, for their number was comparatively small.

To-day the conditions are changed. Home work is probably more limited in proportion to the number of engineers engaged; foreign work is perhaps not so plentiful, as will be explained later on. Professional etiquette is not at the old high-water mark. Work is taken on by some at absurdly low fees, and subterfuges are resorted to by others to attain their ends.

Turn in whatever direction one will, we are now confronted with the unpleasant fact that our citadel is attacked by foreign engineers imbued with dissimilar pro-

fessional ideas to those which were inculcated in us. Furthermore, our foreign competitors have succeeded in capturing parts of our stronghold, and no "tariff reform" policy will affect them nor will it retard their further progress and success.

It is probable that in London the percentage of foreigners is as great as in any other city in the world, but it is, however, certainly in excess of the proportion of Britishers in foreign cities.

Hitherto the foreign and colonial fields were proudly held by ourselves. This monopoly is, however, gradually disappearing, as our foreign friends—who are capable business men, experienced engineers, splendidly equipped, excellently trained in work which we neglect and even ignore, and gifted with dogged pertinacity of purpose, like little drops of water which ultimately erode the hardest rock—eventually succeed in the purpose. The Author certainly does not desire to disparage the British engineer, believing, however, that it is our duty to study our defects and, if possible, to introduce effective improvements. Experience has clearly shown that where we adapt ourselves to new conditions and requirements at home and abroad, we have nothing to fear. The fact, nevertheless, remains that whilst we are more or less lethargic in the adoption of new methods, new ideas and new developments, our rivals respond more readily. Given similar conditions and equal training, the British engineer is difficult to excel for the quality, durability, practicability and economy of his work.

Our foreign confrères are not governed by similar sentiments with regard to, say, advertisement. They believe in bringing their names before the public to obtain work and succeed in doing so, whilst we are debarred from advertising, and suffer accordingly.

Even at the risk of being considered unconventional, the Author would wish to enquire whether it is a serious transgression of professional etiquette to advertise in any manner? Is it derogatory to the dignity of our profession that advertisement in any form should be tolerated? If it is permissible in one form, what equitable force can there be in any argument against it in another form? Would a judicious indulgence in self-announcement result in the deterioration of our profession? Is the engineering profession, which, as Mr. J. C. Inglis, M.Inst.C.E., stated in his presidential address, "is like most commercial (and other) interests passing through a period of rapid development and change, and from its very nature

must be more susceptible to change than its fellow professions of the law, medicine, etc."—still to adhere to an ancient unwritten law debarring the insertion of, say, a card in the technical papers and in the directories? No reputable engineer would resort to flaming announcement such as we see in connection with certain proprietary articles, and even if such an indiscretion was indulged in, would it not carry its own condemnation and retribution?

The means adopted by some gentlemen under present conditions for bringing their names before the public certainly do not imply a divorce from the suggestion of self-announcement, and the methods adopted in some instances to attain certain ends do not appeal to us as dignified and honourable.

The Author is not enamoured with the idea of advertising, but the important question to be borne in mind is what should be the attitude of our organisations in regard to the position of a large number of fellow engineers, to whom it is a plain problem of the "right to work," and also what is conducive to the common good of the profession?

Your Society has undertaken the work of registering the names of all who desire assistance in the search for employment, and the Institution of Civil Engineers and the Society of Engineers are also attending to this matter. The success of the undertaking, however, depends on the number of applications made by employers, which, being insignificant, does not solve the problem.

It is remarkable that whilst many sections of other professions and trades have organised their forces for the benefit of their members, we are singularly bereft of any recognised organisation, which has for its object the collection and supply of information on various matters, including employment, qualification, emolument, investigation, etc., in various countries.

The Institution of Civil Engineers and other societies of similar character are excellent so far as concerns the provision of mental pabulum. As you are doubtless aware, the charter of the Institution of Civil Engineers, for instance, specifically states that the society was formed "for the general advancement of mechanical science, and more particularly for promoting the acquisition of that species of knowledge which constitutes the profession of the civil engineer, being the art of directing the great sources of power in Nature for the use and convenience of man." The principal object was, conse-

quently, that of education, the others being merely secondary, and therefore left to the individual initiative of the members.

It is not, however, surprising that the need for an established and recognised body to attend to the secondary requirements of the profession, or, in other words, their material welfare, has not hitherto been considered of pressing importance by the profession at large, for, as long as the British engineer virtually had a monopoly of foreign and colonial work, and whilst the quantity of work undertaken by the public authorities and companies at home afforded ample scope, this question was not an insistent one. The great distances which separated engineers doubtless tended to render the need for such an organisation almost unnecessary. Such circumstances contributed to our weakness. Personal insularity characteristic of Britishers was inimical to concerted action, but distance can no longer be a barrier, modern engineering inventions and developments having long since removed them. Our ambition to ensure continued success is paramount in our thoughts, and the determination to maintain our position in the engineering world surely indicates that there is now an urgent necessity for collective action, to bring British engineers throughout the world into closer and more intimate relationship with each other, thus creating a powerful factor tending towards an united fraternity, having as its keynote a community of interests, objects and purposes.

The commercial side of British activity has been well provided with agencies for bringing all parts of the world into immediate touch with large and multitudinous industries of our land. There is scarcely a colony or a foreign community without a British Chamber of Commerce to represent its interest, and in intimate connection with similar bodies at home. These lines of communication again are greatly extended by the Board of Trade Commercial Intelligence Department, which periodically receives reports for the use of our trading communities from consuls in almost every corner of the known world. There is also an Advisory Committee associated with this department, consisting of eminent gentlemen, but, so far as the Author has been able to ascertain, not a single engineer. Now it will be at once apparent to you that this is a serious defect.

Some nations may prosper and continue in a morbid, self-satisfied existence for a considerable period, but nations, like individuals, cannot always live unto them-

selves, and when eventually they are awakened to the value of modern ideas and developments as we have observed in Japan, China, South America and elsewhere, the engineer, as "the priest of material development of work, which enables other men to enjoy the fruits of the great sources of power in nature, and of the power of mind over matter," is called in to perform his pioneering mission.

As a well known politician once said, "the opening up of the internal communication of a country is undoubtedly the first and most important element of its growth in commerce and civilisation." Immediately a nation wakes up to the possibilities that are open to her, the essential person to give life to her aspirations is the engineer, for he is able to create the demand for materials and machinery in connection with roads and railways, canals and harbours, structures and bridges, water, gas and electricity supplies, mines, etc., and the manufacturing and commercial people follow in his trail.

"The trade follows the flag" is a trite saying, but who effectually plants the flag? It is, of course, quite feasible to trade with savages, but business with them is necessarily limited. Introduce, however, modern tools, be they railways, steamships or factories, and the savage recedes to the wilderness, and his place is occupied by people of different calibre and requirements.

The omission on the part of the Government to effectually study the interests of engineers is one which requires careful consideration. The Author is fully aware that some British consuls are alive to the need for advising as to what is taking place and furnish valuable information, but it would seem that whilst they are impressed with the importance of watching purely commercial matters, the consuls as a body are not technically equipped with the training which is essential for investigating problems entailing engineering details. Furthermore, as many of our consular representatives are not Britishers, their bias must as a natural result be inclined towards their own nationality. If the reports are carefully studied, it will be found that much of the information is annually stereotyped and too ancient to be of practical use.

The frequent publication of American and other consular reports renders them more valuable, and the patriotic spirit which pervades them is very evident.

The German and other governments appear to consider the success of their engineers in foreign lands almost

tantamount to a national affair. Investigations are organised, information collected and disseminated, advice and support readily given, and even political influence brought to bear with the view of ensuring success.

Whilst the dignified British methods of promoting our interests in other countries are probably more in consonance with our ancient national ideas, there can be no doubt that there is ample opportunity for an increased measure of co-operation on the part of our representatives in the development of our country's welfare in which our profession is indissolubly associated.

It is but just to state that there are brilliant exceptions in this matter, for some of our representatives are very energetic, sympathetic and patriotic, which is evident by the tone and frequency of special reports prepared and forwarded by them.

Enterprise on the part of engineers would effect great improvement in the matter of collecting information on questions concerning their interest in other countries. It is a debatable question whether the Government should alone undertake this work. So much has been done by private enterprise that a dependence on a paternal Government might retard our progress, stifle our individuality, and affect our vigorous independence; yet the Government, with its enormous official ramifications to every known part of the world, could afford most valuable assistance, as the consuls and other representatives could supply information which would not otherwise be available.

Although finance is not an engineering matter, it is, nevertheless, very intimately connected with the problems which we are called upon to solve, more especially on foreign work. Foreign and colonial engineering undertakings involving large expenditure of money are often lost because there are no national or public financial organisations to render the essential support, even when the schemes are sound propositions, and excellent securities are offered.

The fact that a small number of firms are able to secure important foreign contracts clearly indicates what can be done when ample capital is available.

This is another phase of the organisation of British engineering which needs urgent consideration on the part of our public-spirited men, to enable effective competition with well organised foreign professional and commercial enterprise. There is evidence that our foreign and colonial business is not sufficiently cultivated, and if we

neglect this or allow our competitors to gain an ascendency over us, as there is room to fear is being done, what will be the result?

In the matter of research work, comparatively little has been done by our representative institutions. For instance, during its existence of ninety years the Institution of Civil Engineers have conducted researches connected with the "Thermal Efficiency of Steam Engines" and "Methods of Conducting and Tabulating Engine and Boiler Tests," they have investigated the question of "Education and Training of Engineers," and it is understood that at present investigations into the properties of reinforced concrete are being made. Some work is, however, conducted at the National Physical Laboratory out of funds granted by the Institution. It is legitimate to suggest that a much larger volume of work of this character should be undertaken, and there are many subjects which will doubtless occur to you as worthy of experimental investigation.

It is interesting in this connection to recall the circumstances under which our predecessors carried out their monumental works. Brindley, "the father of inland canal navigation in England," was originally a labourer, illiterate, but of marvellous intellectual capacity, and Telford was a mason with the same indomitable will power. The works they executed were original in character, well designed and admired by all. The data they had were most inadequate. There were no precedents to guide them, nor many capable men to assist them. The difficulties were enormous, yet they successfully surmounted them all. In their days, and even much later, there were no efficient testing appliances. The use of machinery was limited. Few standard technical books and very few technical periodicals were then published.

To-day we have literature in ever increasing abundance, circulating libraries, press cutting agencies, catalogues in countless styles and sizes, the careful perusal of which is simply an impossibility. It is often necessary to employ subordinates to blue-pencil the items of interest, so that the principals may keep up with the rapid changes which are taking place. Agencies such as the "Engineers' Standard Publication Association" are proposing to simplify our office library arrangements by classifying, filing and indexing the great and promiscuous variety of machinery lists now pouring into our offices.

It will be evident that to adequately discuss the various questions of importance to our profession is beyond the

limits of a single paper, and therefore these observations must now draw to a close.

During the last few years the subject of the paper has occupied much of the Author's time and thought, and the question has steadily increased in importance. Having observed how enterprise, energy and modern methods on the part of our confrères in other lands have resulted to their advantage, there is scarcely room to doubt that the time has arrived for tangible improvements in our organisation.

There is always ample scope for improvement in every sphere of life. Old ideas, traditions, conditions, constitutions and systems are perpetually in course of destruction to give place to new ones (just as Old London disappears under modern conditions), not because they were unsatisfactory, but because, however good and useful they were in the past, they do not adapt themselves to the requirements of the times.

Although no criticisms are directed to the parent or other institutions, the councils of which are elected by the members, and consist of eminent engineers capable in administration and discerning in their judgment, yet old institutions are apt to follow grooves and overlook the modern requirements of the profession, and it is free to all to express their opinion on the situation.

These institutions were, as has already been stated, established primarily for educational purposes, in which respect they stand pre-eminent among the institutions of the world; but in other matters our organisation is inferior to those of the trade unions.

The establishment of a British Engineer's Bureau has often presented itself to the Author as one scheme which, with the co-operation of the Government and other departments, would aim to remove many of the disabilities afflicting the members of the profession. The functions of such an organisation would be those discussed in this paper, so far as they apply to the material welfare of the members.

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OF THE

CIVIL AND MECHANICAL ENGINEERS' SOCIETY.

(*Founded May, 1859.*)

50th SESSION, 1908—1909.

(JUBILEE SESSION.)

EDITED BY

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Hon. Secretary.

London

PUBLISHED BY THE SOCIETY,

25, VICTORIA STREET, WESTMINSTER, S.W.

(Telephone, 244 Victoria.)

1909.

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